See Pluto From Your Backyard

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A New Look at the Moon's Beginnings

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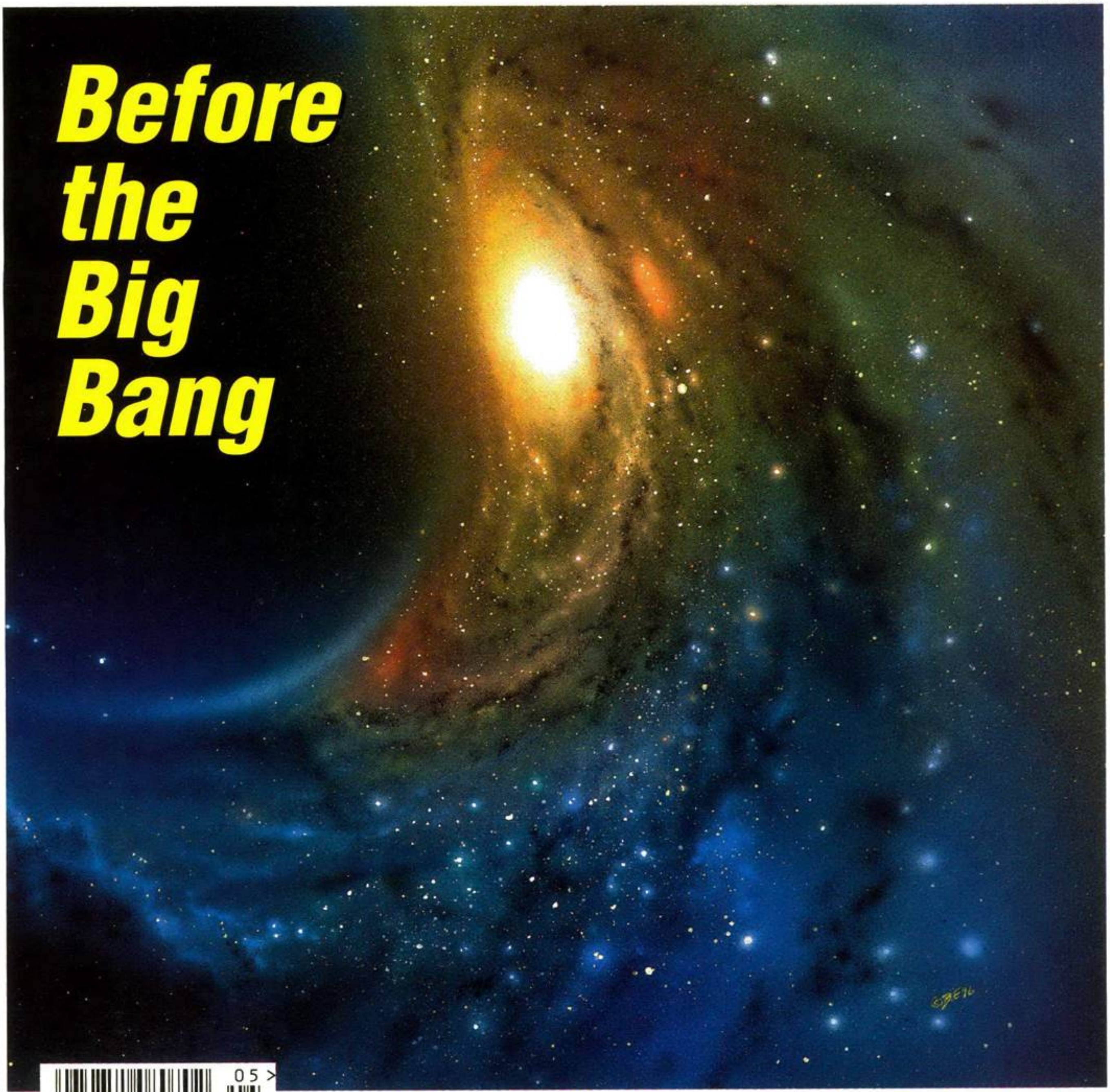

Before the Big Bang

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Where to Find Summer Star Party Action

Dying Stars Challenge Age of Universe

MEADE
7" LX200
8" LX200
10" LX200
12" LX200
7" LX50
8" LX50
10" LX50
4" ED/APO
5" ED/APO
Starfinder Equatorial 6"
8"
10"
6" ED/APO
7" ED/APO
16"
Starfinder Dobsonian 6"
8"
10"
12.5"
16"
STARFINDER MEADE

Price Increase Announcement

A general increase of 8% to 17% in the prices of almost all models of Meade astronomical telescopes will take place on May 1, 1996.

Over the past five years the Meade Instruments factory in Irvine, California, has been continuously updated into one of the most modern, most efficient facilities in the world for the manufacture of precision astronomical instrumentation. This utilization of the very latest in high-technology equipment—in Meade optical fabrication and coating rooms, in the machining department, in telescope testing and quality assurance, and in instrument assembly—has enabled us to maintain stable pricing levels for the great majority of the more than two dozen astronomical telescope models that we manufacture. In some cases prices for Meade telescopes have not increased in more than three years, despite numerous technical improvements that have been put in place on every model during that period.

We believe that Meade LX200's, LX50's, ED/APO's, and Starfinder Equatorials and Dobsonians represent the very best in American technology—a fact confirmed every day by the large numbers of Meade telescopes that we export around the world. In spite of the formidable pricing competition that we face in many foreign countries, Meade astronomical telescopes have attained a predominant position in virtually every country.

Notwithstanding the success that Meade Instruments has achieved, a success for which we are profoundly grateful to amateur astronomers in the United States and worldwide, even Meade technology and manufacturing efficiency have their limits. It is for these reasons that the prices of Meade astronomical telescopes must undergo a general price increase.

We are making this advance announcement of the May 1, 1996, price increase in order to offer a final opportunity for our customers to purchase a Meade telescope at current prices. Even at their new prices, listed below, Meade telescopes will still represent, by far, the finest values available in quality astronomical instrumentation.

Price increase announcements, however uncommon they may be at Meade Instruments, normally result in a substantial increase in our manufacturing backlog. We therefore urge an early purchase of the Meade model you are considering, to avoid a long waiting period.

Meade Telescope Model	*Current Price through April 30, 1996*	*New Price effective May 1, 1996*
8" LX200 Schmidt-Cassegrain	$2495	$2795
10" LX200 Schmidt-Cassegrain	2895	3195
12" LX200 Schmidt-Cassegrain	3995	4495
7" LX200 Maksutov-Cassegrain	2995	3295
8" LX50 Schmidt-Cassegrain	1195	1395
10" LX50 Schmidt-Cassegrain	1495	1695
7" LX50 Maksutov-Cassegrain	1595	1795
4" ED Apochromatic Refractor	2495	2795
5" ED Apochromatic Refractor	2995	3295
6" ED Apochromatic Refractor	4495	4995
7" ED Apochromatic Refractor	5495	5995
Starfinder Equatorial 6	599.95	649.95
Starfinder Equatorial 8	699.95	749.95
Starfinder Equatorial 10	799.95	879.95
Starfinder Equatorial 16	2495	2695
Starfinder Dobsonian 6	325	349
Starfinder Dobsonian 8	425	469
Starfinder Dobsonian 10	595	649
Starfinder Dobsonian 12.5	795	895
Starfinder Dobsonian 16	1095	1195

Prices shown are suggested U.S. national mail-order retail prices, exclusive of any applicable sales taxes or credit card charges, and do not include packing and shipping. Specifications for Meade telescope models are listed in advertisements elsewhere in this magazine issue, or contact your authorized Meade Advanced Products dealer for complete information. The 76-page Meade 1996 General Catalog is available directly from Meade Instruments at $3.00, forwarded by first class mail.

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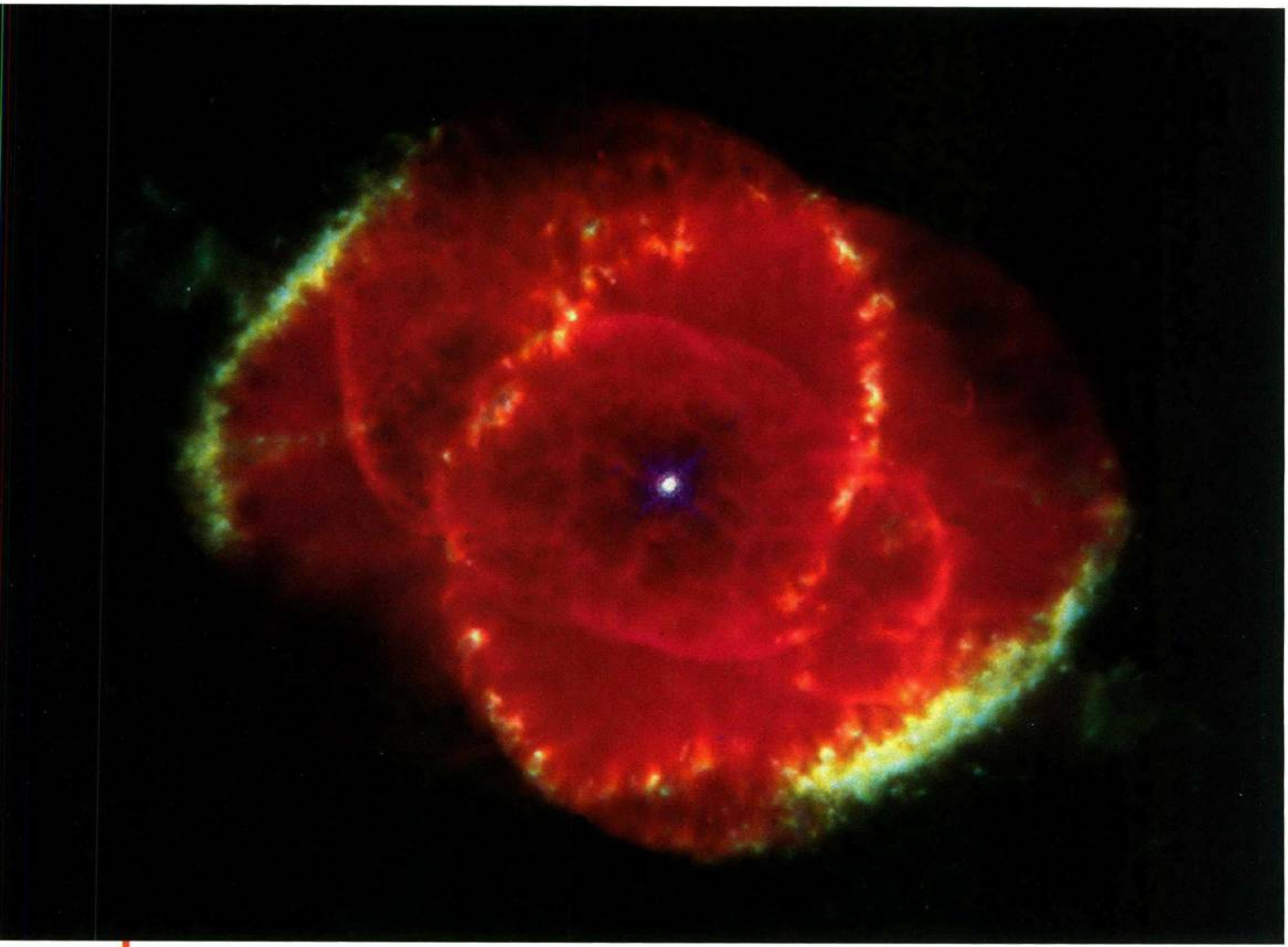


42 Dying Stars Challenge Age of Universe

STScI and NASA

34 What Happened Before the Big Bang?
Join theorists as they probe the "multiverse" that may have spawned our universe, and many others. By Michio Kaku.

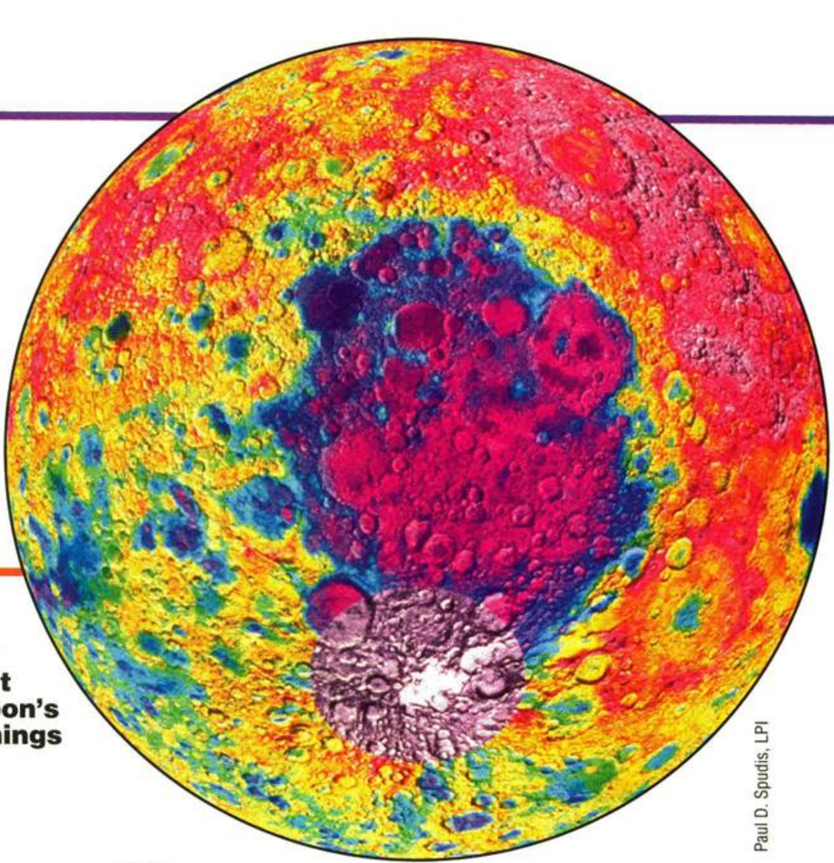
42 White Dwarfs Confront the Universe
Dying stars as massive as the Sun but no bigger than Earth are helping astronomers zero in on the age of the universe. By Ken Croswell.

50 The Giant Holes of the Moon
The Clementine spacecraft's study of ancient lunar basins revealed new features and showed how the biggest impacts churned up rocks buried deep in the crust. By Paul D. Spudis.

56 Sky Almanac
May offers Venus shining brilliantly at dusk, a pair of bright asteroids, and an occultation of Comet Hale-Bopp by the Moon. By Jeff Kanipe and Alister Ling.

ON THE COVER

HOW DID THE UNIVERSE ARISE?
The latest theories suggest ours formed in an exotic multiverse that spawned many parallel universes. For more on our surprising origins, turn to page 34. Painting by Bob Eggleton.



Paul D. Spudis, LPI

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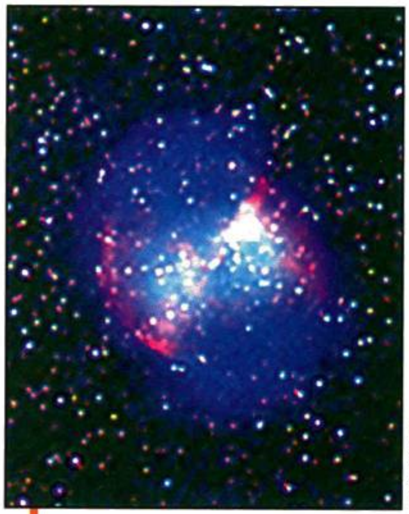
A New Look at the Moon's Beginnings

Don't Miss This

Tim Puckett

82 A Comet Crap Shoot



Jack Newton

72 Meet the Milky Way

66 The Star Partier's Guide to Summer

There's no better way to enjoy your hobby than to share in the excitement and camaraderie awaiting you at this summer's star parties. By John Shibley.

70 Observing to the Edge

Our detailed charts will have you viewing Pluto in no time. By Richard Talcott.

72 Meet the Milky Way

From naked-eye star clouds to telescopic challenges, the summer Milky Way offers something for every observer. By David J. Eicher.

78 The Starsplitter Compact

These Dobsonians proved rugged and remarkably portable. By John Shibley.

82 A Comet Crap Shoot

Comet Hyakutake should put on a sterling show this spring. By Jeff Kanipe.

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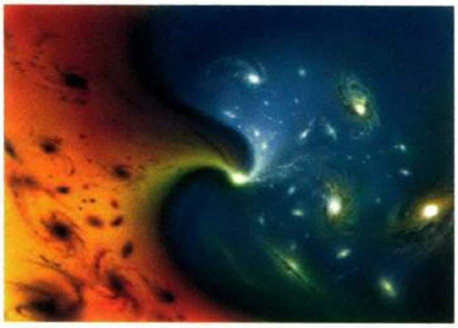
Before the Big Bang

If the big bang is mysterious to most people, trying to get a handle on what happened *before* it seems downright impenetrable. Yet as you'll see from our lead feature this month, the subject isn't totally out of the realm of discussion.

Okay, so what did happen before the Big Bang?

Well, I'm not going to try to summarize Michio Kaku's whole presentation right here. I'll just direct you to his story — see page 34. Mysterious or not, the big bang tends to evoke strong reactions from people, probably because they feel it has become a kind of scientific orthodoxy. That's a topic for another day, but whatever your feelings are about the issue, I think you'll agree there are few more interesting subjects in all of astronomy.

Another kind of "big bang" takes place this month in the universe of backyard astronomy. May traditionally marks the start of summer observing, bringing with it star parties, club openhouses, and the more social side of skywatching. Over the past decade we have seen the number of star parties grow remarkably. Two years ago we profiled a handful of the better-known meetings. This year we list over twice as many. And there's an awful lot more going on around the country.


Bob Eggleton

Picturing the unpicturable

So if you are one of those who has never visited a star party, associate editor John Shibley just took away your best excuse (see page 66). Read it carefully, look at your vacation plans (and the road atlas!), and get in on all the fun. It's never been easier, and I'll bet there's at least one meeting this summer within easy reach of where you live.

One Milwaukee radio announcer always ended his programs with the exhortation to "find a concert and go to it." Well, I think you should find a star party this summer — and go to it!

Sincerely,

Robert Burnham

Robert Burnham
Editor
rburnham@astronomy.com

LETTERS

Relativity of Heaven

Jeff Kanipe's article (Forum, February 1996) was the first I have ever read in ASTRONOMY that did not further my knowledge of the universe. How would Galileo respond to the statement, "Never let it be said that the Church isn't good for you"? Mr. Kanipe also suggests we "admit it's fun to think of the implications" relating the properties of a singularity with the concept of heaven.

Here's a thought that isn't fun: ASTRONOMY has established a high degree of integrity by the quality of the material it publishes and the scholarship of the contributors and editors. To lend the magazine's academic credibility to the nonsense in this article is a breach of that integrity. The losses in knowledge, liberties, and even lives scientists have suffered in promoting reasoning over mysticism covers this article

[continued on page 16]

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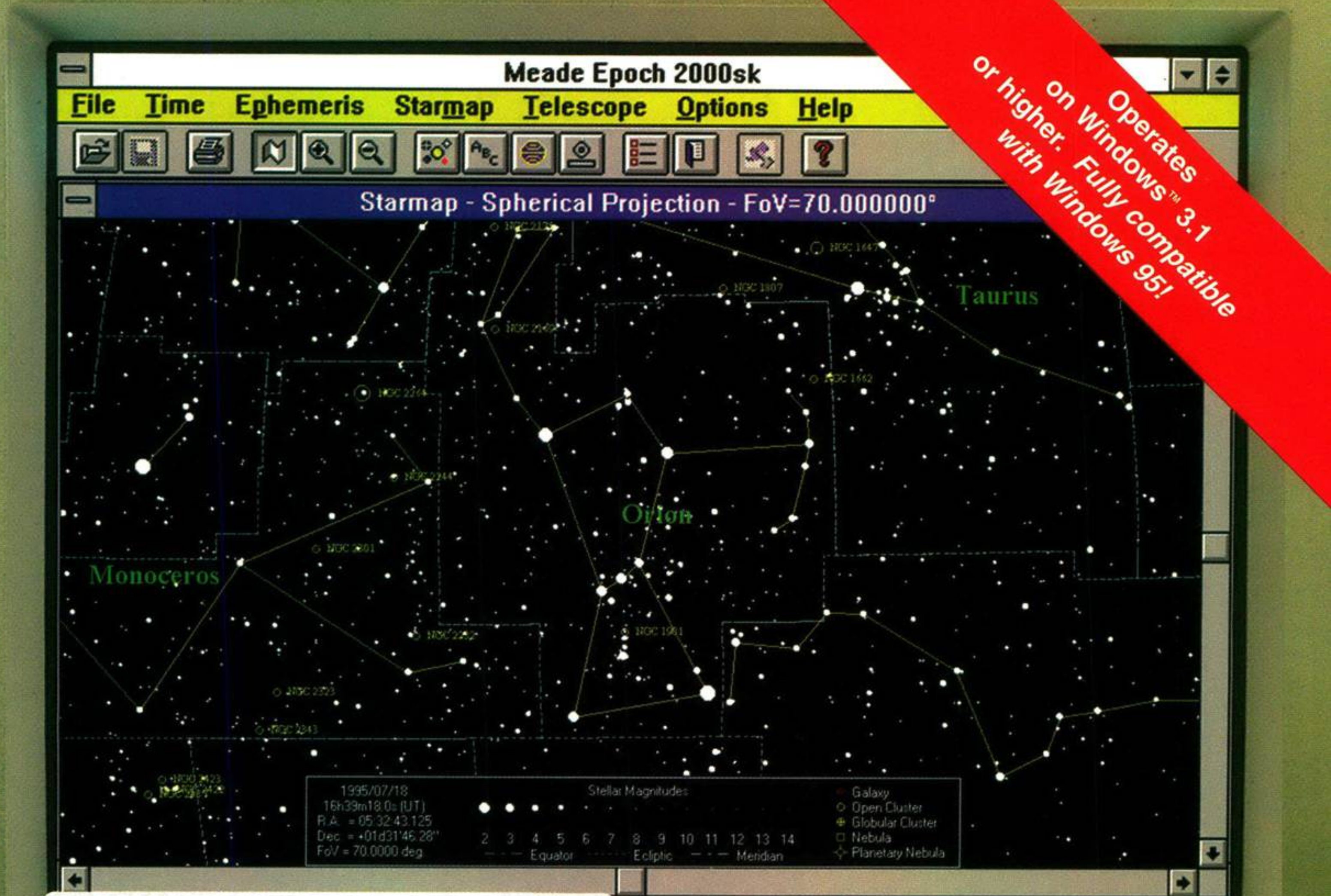
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LX200

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In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models ***combined***. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of over 64,350 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
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SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); complete operating instructions.

8" LX200 Schmidt-Cassegrain	**$2495.**
10" LX200 Schmidt-Cassegrain	**2895.**
12" LX200 Schmidt-Cassegrain	**3995.**
7" LX200 Maksutov-Cassegrain	**2995.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

ADE

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LX50 models shown with optional Field Tripod.

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- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.
- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.
- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

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Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), completely concealed in special LX50 encoder compartments. ■ Quick 2-star alignment. ■ Large 32-character, red-backlighted display. ■ 4-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

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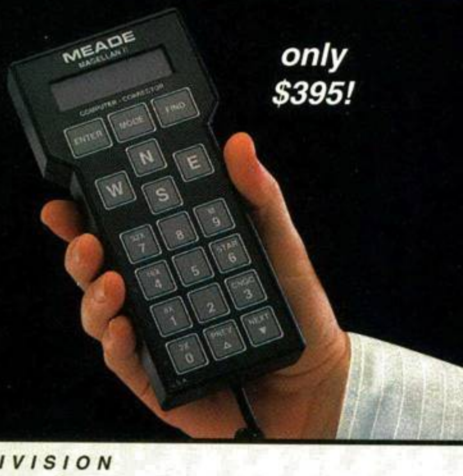

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All models shown with optional #637 6 x 30mm or #545 8 x 50mm viewfinders.

Compare *feature-for-feature* with other similarly priced Dobsonians!

■ **Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass:** Unlike the plate glass optics of other Dobsonians that can become thermally unstable (especially in larger apertures), Meade Dobsonians are made of Grade-A, fine-annealed Pyrex—the exact same professional-quality optics used on Meade Starfinder Equatorials.

■ **Precision Components:** Including a full-size rack-and-pinion focuser (1.25") with 2.6" travel and fully-adjustable *4-vane* secondary mirror system.

■ **Rigid, Durable, Beautiful Dobsonian Mountings**, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the location and tracking of celestial objects.

■ **Optical Tubes:** Starfinder Dobsonians include the same strong, spiral-wound optical tubes used on Starfinder Equatorials *(right)*. All telescopes include a multi-coated MA25mm eyepiece; each tube is factory pre-drilled for the optional 6 x 30mm or 8 x 50mm viewfinder.

■ **Performance!** A Meade Starfinder Dobsonian or Equatorial opens up the skies to an extremely wide range of serious visual observing: all 110 Messier objects, thousands of NGC objects—nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning, high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder equatorials may be used, in addition, for lunar and planetary photography and even for limited deep-space photography.

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U.S.A.

Actual Size: 4" x 5" x 1.25"

■ **Easy to Use!** Just input the R.A. and Dec. of the object you wish to observe, or call up an object from Magellan's massive database. Magellan allows you to slew the telescope manually to the object and place it in the visual field, quickly and precisely.

■ **Fast 2-Star Alignment:** Point the telescope at 2 bright stars selected from the star database, and the computer is aligned in *seconds.* No need to input time or date, latitude or longitude. Magellan's powerful microprocessor calculates telescope position in milliseconds and directs your movements of the telescope for fast, accurate object location.

Meade Magellan II Computer-Corrector for Starfinder Equatorials

Plug the Magellan II into the control panel of your Meade DC-powered Starfinder Equatorial *(right)* and you have *all the capabilities of the Magellan I (above)* ***plus*** a 4-speed, dual-axis, drive-corrector/microslewing system!

Includes: Magellan II hand controller *(right)* with 4 dual-axis speed rates (2x, 8x, 16x, 32x sidereal); high-resolution 4096-pulse encoders for both axes; electric Declination control system; 12,218-object computer database; 2-star alignment; RS-232 serial interface. (For Meade *DC-powered* Starfinder Equatorials, only.)

#2018: for Starfinder Equatorial 6", 8", or 10"	**$495.**
#2019: for Starfinder Equatorial 16"	**595.**

Prices plus $20 packing & shipping in the 48 states.

INDER
UTERS

■ **High-Resolution 4096-pulse Encoders:** Each Magellan system includes two premium-grade, high-resolution encoders. Encoder precision is 5.3 arc minutes.

■ **Large 32-Character LCD Red-Backlighted Display:** The same LCD display included with the Meade LX200 hand controller. Includes variable illumination from dim to bright.

■ **12,218-Object Database:** A database that includes an amazing array of objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

■ **Supplied Complete!** With other computers you pay *once* for the basic controller and then pay *again* for the "Encoder Installation Package." Meade Magellan Systems are supplied **complete** with: controller/display unit (4" x 5" x 1.25"); encoders for both telescope axes; RS-232 serial interface; bracket for convenient placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan is ready to use. First-time installation is quick and simple.

Meade Magellan I Telescope Computer Systems

#2010:	**for Meade Starfinder Dobsonian 6", 8", 10", 12.5", or 16"**	**$295.**
#2011:	**for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10"**	**295.**
#2012:	**for Meade (DC-powered) Starfinder Equatorial 16**	**295.**

All prices plus $15 packing & shipping in the 48 states. Prices shown are suggested U.S. national mail-order retail prices. For additional information on Meade Magellan systems, send for your free copy of **Meade Bulletin 2900.**

MEADE
MAGELLAN II
COMPUTER - CORRECTOR
ENTER
MODE
FIND
N
W
E
S
M 9
32X 7
8
STAR 6
16X 4
5
CNGC 3
8X 1
2
NEXT
2X 0
PREV
U.S.A.

MEADE STARFINDER EQUATORIALS

MEADE
MEADE DC DRIVE SYSTEM
12vDC
On
R.A. Encoder

Battery-powered motor drives for fully cordless operation!

16" f/4.5 $2495.

10" f/4.5: $799.95

8" f/6: $699.95

6" f/8: $599.95

Standard equipment on 6", 8", and 10" equatorial models includes:

■ **Superb Optical System:** Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

■ **Precision Equatorial Mount:** Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

■ **Battery-Powered Cordless Drive System!** Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries inserted through the drive cover. Control panel *(see inset photo, above)* also permits powering of telescope from 12v. auto cigarette lighter plug, using optional 25' cord.

■ **Accessories and Components:** Rack-and-pinion focuser (1.25") with 2.6" travel; #637 6 x 30mm viewfinder; multi-coated MA25mm (1.25") eyepiece; strong, durable, spiral-wound optical tube with attractive white finish.

■ **Starfinder Equatorial 16:** Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6"-dia. pier, 6 x AA-size battery-powered worm gear drive, 8 x 50mm viewfinder, #682 giant (2" & 1.25") rack-and-pinion focuser.

Packing and UPS Shipping Charges to any address in the 48 states: 6"–$65; 8"–$75; 10"– $90. 16"–$55 packing, shipped truck freight collect.

To Order: Contact your authorized Meade Advanced Products Dealer. All prices shown are suggested USA mail-order retail prices.

Meade 1996 General Catalog, $3.00 postpaid, is available from your authorized Meade dealer or directly from Meade Instruments.

ACCESSORY OFFER!

At the time you order any Meade Starfinder Equatorial Telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, for a **total of $29.95!** *Purchased separately, the 2 eyepieces sell for $75.90!* Offer valid until further notice.

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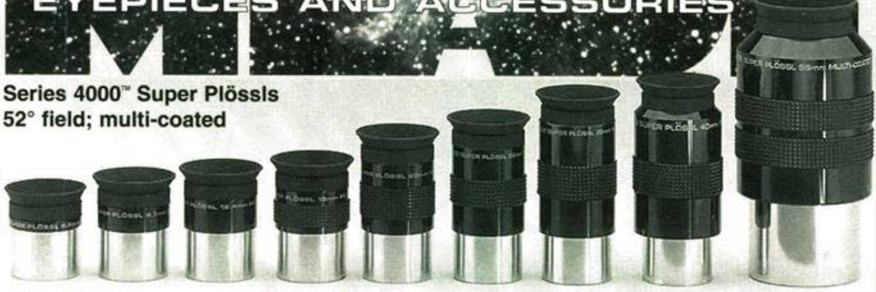
MEADE
EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls 52° field; multi-coated



Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (4.27)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 3000™ Plössls 50° field; multi-coated

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

Series 3000™ Plössl 40mm 44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (5.87)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

HOW TO ORDER

- Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.
CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders & Information: 818-505-8424.
CITY CAMERA, Dearborn, MI.
Orders: 800-359-5085; Info.: 313-846-3922.
FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.
LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.
SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders: 800-621-2248; Info/IL: 312-332-2000.

Canada:
EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.
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FREE! $800 CCD Equipment System!

Now, for a limited time, when you purchase a Meade Pictor 416 or 1616 CCD imager at the regular price, **we'll include an $800 Meade CCD Equipment System—everything you need for advanced CCD imaging—absolutely FREE!** Purchased separately, the CCD Equipment System is priced at $807 and includes these important products:

Meade Pictor 201 Autoguider: Allows completely automatic guiding of your Pictor camera during CCD imaging or your 35mm camera during long-exposure astrophotography.	**$395.**
Meade CCD Off-Axis Guider System: Complete with adapters for 1.25" eyepiece holders and for Schmidt-Cassegrain rear-cell threads. Use with the Pictor 201 on guide stars to 10th-magnitude.	**119.**
Meade CCD Image-Orientation Adapter: Threads into the Off-Axis Guider and permits precise image orientation on the CCD chip.	**35.**
Meade Epoch 2000ip Image Processing Software: Professional Windows-based image processing that permits the enhancement and analysis of CCD images using the most advanced techniques, including dynamic scaling, histogram equalization, image convolution, unsharp masking, median filtering, RGB merging, and more.	**199.**
Meade Foam-Lined Carrying Case (19" x 14" x 7"): Provides for secure storage and transport of your Pictor 416 or 1616 CCD imager as well as all items of the CCD Equipment System described above.	**59.**
Total price of all items if purchased separately:	**$807.**

The Meade Pictor 416 CCD Imaging Camera is packed, at no additional charge, with the **Meade $800 CCD Equipment System** during the period of this special offer.

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MEADE PICTOR
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The Trifid Nebula (M20): Pictor 1616; a 5-minute exposure by Jack Newton with the Meade 7" f/9 *ED* Apochromatic Refractor.

Pictor 201 Autoguider: For flawless, ultraprecise autoguiding during long-exposure astrophotography or CCD imaging. Automatically locks on to guide stars as faint as 10th-magnitude and makes all required dual-axis corrections. Results in perfectly guided astrophotographs or CCD images during even the longest of exposures. Completely self-contained; no host PC required. **$395.** + $10 packing & shipping in 48 states.

Pictor 208 Autoguider/Imager: For an amazingly low price, the 208 gives impressive imaging capability even to the novice. On telescopes of 4" aperture and larger, the Pictor 208 yields very satisfying results and, in addition, is a full-capability autoguider, containing the exact same autoguider hardware and software as the Pictor 201, above. The 208 incorporates the Texas Instruments TC-255 microchip, by far the largest, highest-resolution chip available in any CCD unit in its price range. **$795.** + $15 P & S

Pictor 216 CCD Autoguider/Imager: Identical in operation and size to the 208, the Pictor 216 includes a 16-bit A/D converter for 65,536 brightness levels. The result is a level of image quality only obtainable on competing units that sell for almost twice the 216's price. Combining high-resolution imaging with low dark current, the Pictor 216 satisfies the long-term CCD imaging requirements of the majority of serious amateurs. **$1295.** + $15 P & S

Pictor 416 CCD Autoguider/Imager: Armed with the powerful Kodak KAF-0400 CCD microchip, the Pictor 416 is the most advanced high-resolution CCD system available under $5000. And, with its standard-equipment SCSI interface, the 416 can full-frame download in *one second!* The Pictor 416 is a powerful CCD system on any telescope; attached to a Meade LX200, its capabilities are truly awesome. The auto-mosaic feature, for example, permits the imaging of an arbitrarily large sky area **automatically** on user command. **$2495.** + $25 P & S

Pictor 1616 Autoguider/Imager: For professional-level applications the Pictor 1616 utilizes the Kodak KAF-1600 microchip, one of the largest (13.80 x 9.20mm) CCD chips in commercial production. Identical in pixel density and dark current to the 416, but with *four times* the chip area, the 1616 permits the imaging of very large sky areas: a sky area of 23' x 15' with an 8" f/10 Schmidt-Cassegrain, almost one-half the lunar surface in a single exposure. The 1616 is the finest CCD imaging system available at under-$10,000. **$6495.** + $40 P & S

The special Meade CCD Equipment System offer is effective beginning July 20, 1995, at participating Meade dealers in the U.S.A. and Canada. *This offer is valid until further notice and may be withdrawn at any time.* ■ All prices shown are suggested U.S. national mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable. ■ For safety reasons AC-powered personal computers should be used indoors only. ■ The Meade brochure ***CCD Imaging Made Simple*** is available free of charge, or send $3.00 for the 76-page **Meade *1995 General Catalog.***

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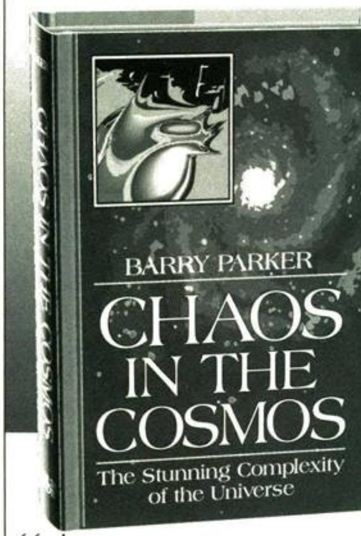

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LETTERS

with shame over its epistemological about-face. — *Henry Shuda, Camino, California*

Mr. Kanipe stated that if one fell into a black hole, time would appear to pass more quickly outside. While the conventional laws of physics may not apply inside a black hole, they remain valid in the rest of the universe. Light from a quasar 10 billion light-years distant would still be seen by the unfortunate observer in 10 billion years; thus if one were not torn apart by the tidal forces and lived forever, one would see the universe age and die, and that truly would be Hell. — *Jim Morford, Tucson, Arizona*

— Jeff Kanipe responds: I think some readers misinterpreted the intent of the Forum column. As its name implies, it is meant to be a place where ideas and opinions are freely expressed and shared. It is not, by design, instructional. Moreover, my essay had nothing to do with the persecution of scientists by religious factions. It is a whimsical musing about how a young boy sitting in church found an unexpected coincidence between religion and science. I haven't the foggiest idea what Galileo would say upon reading it, but I suspect he wouldn't give it as much gravity as did Mr. Shuda.

Photography Ain't Dead, Folks

Thank you for the reassuring comments that film-based astrophotography isn't dead ("Behind the Scenes," November 1995). My goal is to take a few beautiful shots of the Orion Nebula and other objects, and to this end I have invested about $6,000 in telescope, camera, and accessories.

It's been a little disconcerting to hear that film-based photography might become obsolete. I don't want to spend any more on a CCD camera, a computer, and an autoguider. Please keep the coverage of conventional photography alive. — *John D. Wurschmidt, Orangeville, California*

Stolen Scope

In December 1995, amateur telescope maker Steve Swayze's van was stolen with his custom 12.5-inch f/6 binocular telescope inside. The binocs stand about 5 feet tall and are beige with a red rocker box. A plaque commemorating an award at Riverside was attached to the box. There's a photo of the scope posted on the Rose City Astronomers' Home Page at **http://www.teleport.com/~rca/rca.html.**

The scope was stolen in the Portland, Oregon, area, but of course may have moved. Anyone with information will help restore Steve's dream. Please contact us at rca@teleport.com. — *Thurman Miller, Portland, Oregon*

Book Collectors, Unite!

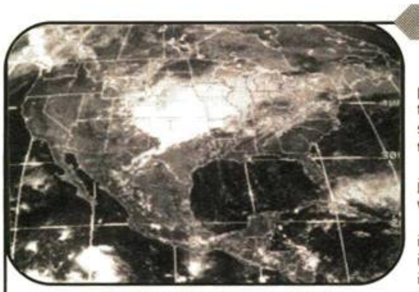
Ever since I became interested in astronomy I've enjoyed collecting and reading old books on the subject. Especially titles that predate 1930. The oldest ones I've found date back to the 1850s. The period includes many great authors like John Herschel, R. A. Proctor, Robert Ball, and many lesser-known writers.

If other readers are interested in collecting old books, and might even wish to set up a society for circulating critiques and essays on the subject, please contact me. — *Philip Hurst, 9, Beverley Hills Mobile Home Park, Porton Road, Amesbury, Wiltshire, SP4 7LH, England*

To Digitize the Sun

I greatly enjoyed seeing the solar images by Don Trombino and Jeff Pettit in Reader Reports (July, 1995). A question arises: Could these three images of the same piece of Sun, taken at different wavelengths, be digitally combined to show more details in the sunspot? Such processing might bring out a wealth of information. Most digitally processed images I've seen show deep-sky objects. It seems a simple matter to scan high-resolution negatives from solar photos into electronic files, and then use the software tools as we do with CCD imaging. — *Dennis O'Connor, Hemlock, Michigan* ☐

ASTRONOMY welcomes feedback. Send it to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or on the Internet use letters@astronomy.com. Letters may be edited for space and clarity.



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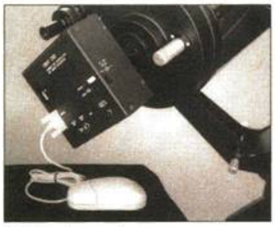

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M42 in Orion, 4 x 4 seconds, 8" f/10

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ASTRO FORUM

Hand-Me-Down Stars

by Dava Sobel

I failed to learn the constellations as a child, though my mother pointed them out to me often enough in her casual way. All those nights we spent bundled in sleeping bags on the deck of my father's boat, she would sit up with her back against the cabin entryway, scanning the spangled darkness over Long Island Sound from horizon to horizon, hour after hour.

"There are the three stars of Orion's belt," she might say, using the tip of her cigarette for a pointer. "Mintaka, Alnilam, and Alnitak."

She knew all the brightest stars by name. She could navigate by them and take fixes on them with her sextant to determine our position at sea. She knew the fables that described each constellation, too. But it was not my mother's habit to impose her interests on any of us. What she shared, she spoke aloud absentmindedly, as though talking to herself, with no formal attempt to instruct my brothers or me in astronomy.

Even when she bought the little home planetarium, which projected true star patterns on the walls and ceiling of our dining room, she intended it for her own amusement. I think she wanted to see the constellations that never appear in the New York skies. After she entertained me with her toy one afternoon when I was home sick from school, I appropriated it to put on make-believe planetarium shows for my friends.

I conjured up the text of my planetarium talks, naturally, since I could not tell one constellation from another. My friends didn't care. They knew nothing about the stars either, but we all enjoyed taking turns with the little flashlight that shone a red arrow at whatever celestial object we pretended to lecture about. The novelty of the gadget was what held our attention, not the stars it represented. Had we been interested in them, we could have followed my mother up to the flat roof of the house, where the bright stellar lights outshone the street lamps on our block. My mother would have been only too happy to interrupt her stargazing reverie to answer our questions.

But we never pressed her to do that. We were too busy amassing fortunes in Monopoly, watching *Gunsmoke*, reading the magazines my older brother hid under his bed. I took my mother's copious store of star lore for granted.

I remember the night all that changed. I was past 40, and well launched on a career as a science writer that had taught me a good deal about cosmology and astrophysics. But, like the radio astronomers I often wrote about – the ones who were so accustomed to observing the alternate electromagnetic universe that they were hard-pressed to pick out the Big Dipper – I was still lost under the night sky.

Dewey Vanderhoff

Then I attended a week-long international science conference in northern California, as part of the research for a book I was writing with one of the speakers. On the last night of the meeting, I walked back to my lodgings along the slow path through the redwood trees. I came out from under their canopy at the edge of a wide sloping lawn, where the stars loomed up and shook the clear air of the moonless night.

The intimacy of the forest fell away, leaving me alone, exposed on the hillside, bearing the full weight of that spectacle.

Vertigo overtook me. Some freak gravitational field spawned by the overweening stars had swept me into its maw. Or I wished it would. I

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FORUM

plummeted headlong into the strangeness of that starscape. And I didn't want it to remain foreign to me anymore. I needed to learn my way at last through the constellations.

I returned home with books, star charts, and planispheres – not so much determined to master a new discipline as drawn to a new love. My children viewed my sudden wish to stay outside on the garage roof all night as evidence of midlife crisis.

"I hope you don't mind," my 13-year-old daughter said as politely as she could, refusing my invitation to view the Summer Triangle, "but I really don't want to be an astronomer." I understood exactly what she meant. I saw my own history repeating itself in her, like a family curse.

So most nights I come out here alone. I get into my Star Boat, a moldy old black-and-yellow inflatable rubber dinghy that the mother of one of my son's friends donated to my cause, and stare straight up, into the deep.

I fancy myself one of the ancient stargazers of China or Mesopotamia, who used to ascend stone steps to the top of a ziggurat because they believed the summit brought them nearer to the heavens. Of course I know better; I just get above the tree line to escape the biting bugs. And maybe sidle back to my mother's former post on the rooftop of my youth.

I don't own a telescope. I don't even want one. I figure the great 16th-century astronomer Tycho Brahe could identify some 800 stars with his naked eye alone. When I know the names and positions of that many, I'll consider upgrading my equipment. Meanwhile, the rubber dinghy, and sometimes a pair of binoculars, are all I need to recoup my rightful inheritance. For on those crystalline nights when the Star Boat seems to levitate off the garage roof into what is now familiar territory, I feel inextricably linked to all stars and all stargazers of all times. □

Dava Sobel's book Longitude, *published by Walker and Company, recently made the* New York Times *bestseller list.*

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ASTRO NEWS

51 Pegasi Planet Update

Poor 51 Pegasi B. First it had its moment in the spotlight eclipsed by the discovery of two new planets. And now the planet — the first to be discovered orbiting a Sun-like star — appears to be alone. When Swiss astronomers Michel Mayor and Didier Queloz published their discovery in the November 23, 1995, *Nature*, they reported evidence for a second planet orbiting farther out from the star. But observations over the last few months by several different teams show no hint of a massive second planet. If there are more planets circling 51 Pegasi, they are either small or orbit the star at very large distances.

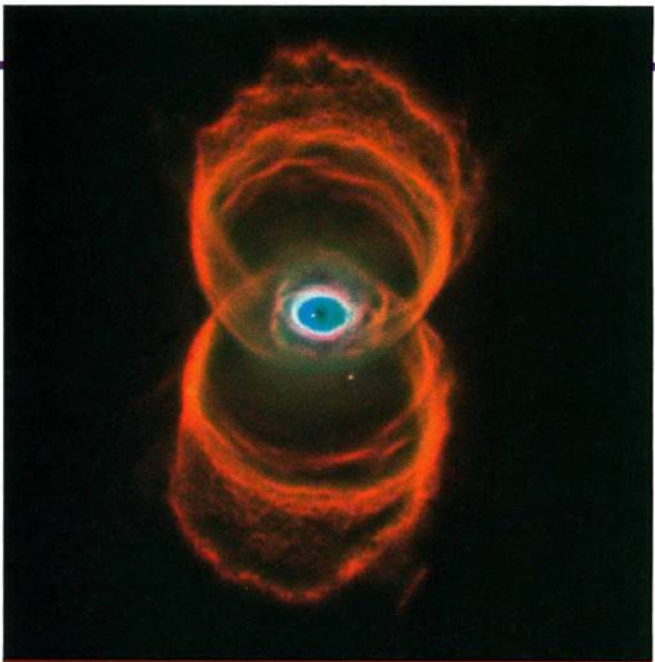
A consensus is beginning to emerge as to how this big Jupiter-mass planet got within 1/8 the Mercury-Sun distance from its host star. Most astronomers now think the planet was a gas giant that formed much farther from the star. Then, over hundreds of thousands of years, gravitational interactions with clumps in the protoplanetary disk robbed some of the planet's orbital energy, dragging the planet toward the star.

Planets that formed interior to 51 Pegasi B presumably spiraled all the way into the star. But two proposed mechanisms could have allowed the big planet to escape immolation. First, a fast-spinning young star could have transferred angular momentum to the planet, giving it an outward boost. Second, the young star might have possessed a powerful magnetic field that cleared the inner part of the disk before the planet could spiral to its doom.

Mars Better than Earth For Early Life?

Mars may have been a more hospitable place than Earth to start life, theorizes planetary scientist Norman Sleep of the University of California, Santa Cruz. Sleep studied how a large ocean might affect the surface temperature of a planet in the aftermath of big impacts such as those that were common in the first billion years of both planets' histories.

His computer models gave the surprising result that a planet (such as Mars) that lacks an ocean recovers faster from a big impact than does one with a substantial volume of water at the surface, as Earth did from its early days on. With a basically dry planet, a big impact heats the surface rapidly — but the surface then cools quickly, recovering in perhaps just a few



AN HOURGLASS AND AN EGG. These two nebulae surround dying stars. The one above, MyCn18, is a young planetary nebula 8,000 light-years away. A fast wind of gas ejected by the star right before it collapsed is catching up and plowing into a slower wind ejected several thousand years earlier, sweeping the gas into a thin shell like a snowplow. The slow wind was extremely dense along the star's equator, allowing the fast wind to escape much faster at the poles, creating the hourglass shape. Surprisingly, the star and the central oval are off-axis with respect to the hourglass, giving theorists something to ponder in the coming months. The object below is the Egg Nebula, lying about 3,000 light-years away. The central star is becoming a white dwarf. The concentric shells represent 10,000 years of gas ejected from the star while it was still a red giant. A cocoon of dust hides the central star. The "searchlight beams" might be starlight punching its way through ring-shaped holes in the dust.

R. Sahai and J. Trauger (JPL), and NASA

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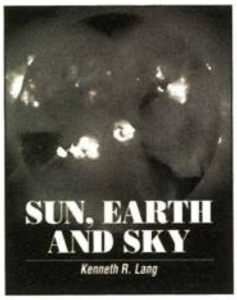

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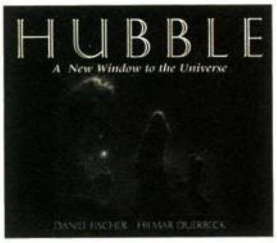

Written in a style appealing to amateurs and professionals alike, this visually impressive compendium serves as a testament to the significant role the Hubble Space Telescope has played in astronomical accomplishment and discovery the past five years. The authors use new and ground-breaking Hubble results to illustrate a wide range of astronomical topics, from the great questions about the Universe as a whole to quasars and black holes, and from the life and death of stars to our planetary neighbors in the solar system. Contains over 140 spectacular images, 80 in full color.

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months. But on a planet with a large ocean, while big impacts may not heat the surface as much, the ocean retains heat better and the surface stays hot for decades or centuries.

Early life on Earth must have been quite tolerant of heat, says Sleep. And, he notes, it may have started several times, being wiped out by impacts each time but the last.

Sleep's findings also imply that life is even more likely to have begun on Mars, since the conditions on both planets differed not too much at first, Earth's global ocean apart. But if life ever did begin on Mars, it must have died out relatively soon as environmental conditions turned hostile. Mars today appears completely sterile, but "exo-paleontologists" are hoping that future Mars missions may be able to look for fossil evidence of life.

Sleep reported on his work during the annual meeting of the American Geophysical Union in December last year.

A BETTER CRADLE FOR LIFE than Earth? New theoretical work suggests that the lack of an ocean on Mars may have minimized the damage of large impacts early in the planet's history, thus affording life a better chance to gain a foothold than it had on Earth.

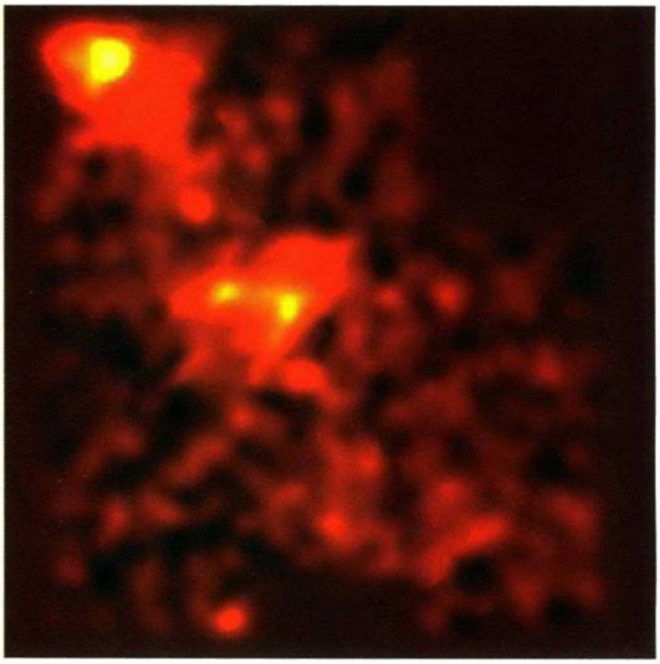
NASA/JPL

The Once Active Milky Way

Many astronomers think a supermassive black hole weighing in with the mass of a million Suns lurks in the heart of our galaxy. But if that's true, ask the cynics, how come there is so little X-ray emission screaming out from the core, in contrast to active galaxies, which almost certainly harbor monster black holes?

Black-hole believers have new ammunition to fire back at their critics. The Japanese-American ASCA X-ray satellite has produced strong evidence that the core was violently active just a few hundred years ago. ASCA discovered an oval-shaped cloud of highly ionized gas extending 300 light-years from both sides of the galactic center. The cloud, which has a temperature of several million kelvins, contains the energy of several thousand supernova explosions. Yet it's highly unlikely that so many supernovae exploded in such a small region of space. The energy heating this cloud probably came from the core. Researchers also found that a gas cloud near the galactic center known as Sagittarius B was glowing brightly in X rays, and the energy that heated it presumably originated in the core. "The most probable solution is that the galactic center was about 10,000 times more luminous 300 years ago," says Katsuji Koyama of Kyoto University.

The ASCA results indicate that the galactic core's X-ray engine turns on and off intermittently, and that a supermassive black hole indeed lurks in the heart of the Milky Way (see "A Quiet Beast," AstroNews, September 1995).



Kyoto University

THE HOT ZONE. Ionized gas surrounds the Milky Way Galaxy's center, indicating the core was more active as recently as 300 years ago.

A Black Hole Rocket

In 1992 the Hubble Space Telescope imaged the core of the elliptical galaxy NGC 4261, 100 million light-years away in Virgo. A swirling disk of gas and dust indicated the

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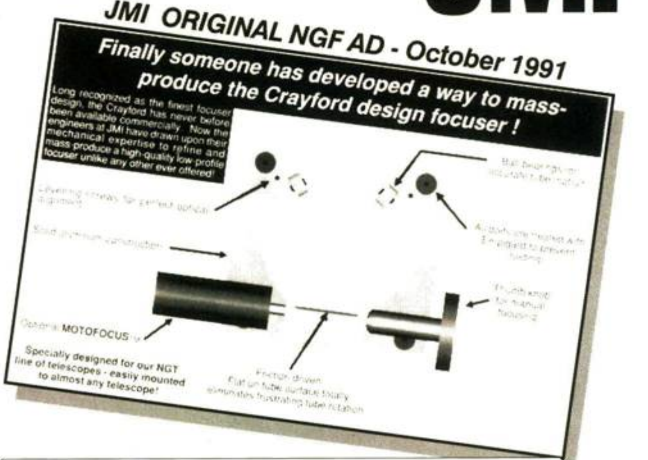

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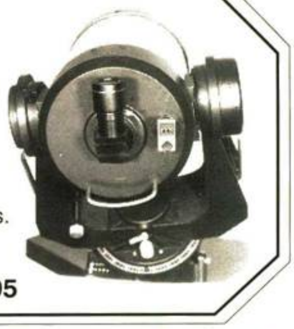

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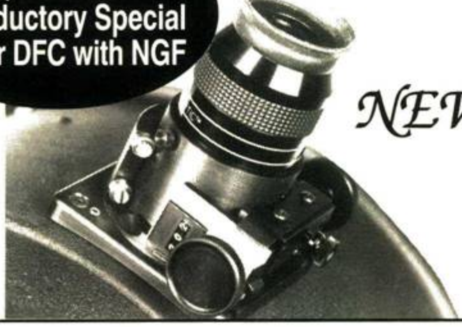

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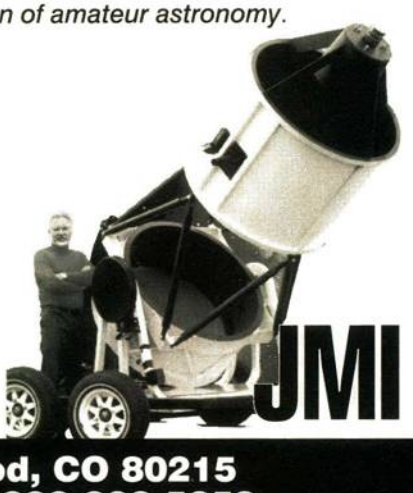

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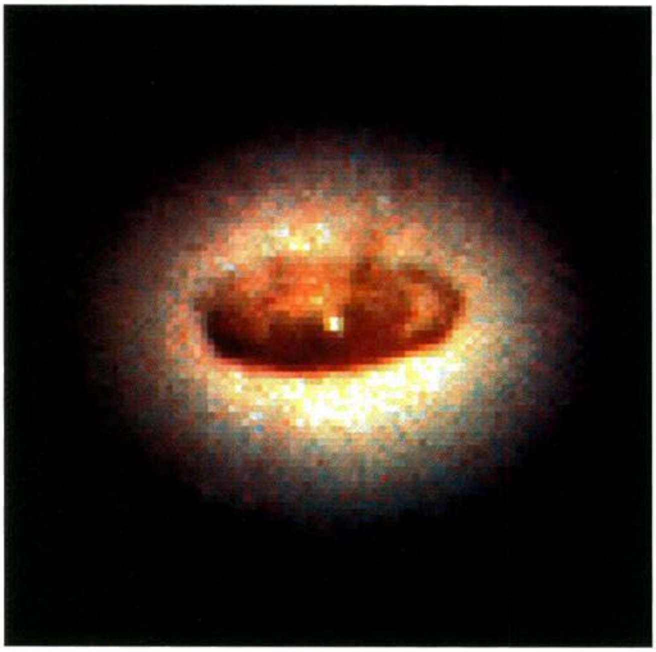
STScI

A MONSTER BLACK HOLE lies inside this disk, but not at the exact center.

existence of a monster black hole. In 1995 the refurbished Hubble took a closer look, showing greater detail in the 800-light-year-wide disk surrounding the black hole. By measuring the speed of the spinning disk of material, the imaging team, led by Holland Ford and Laura Ferrarese of Johns Hopkins University, was able to determine that the black hole weighs in at 1.2 billion Suns. This incredible mass is crammed into a region of space not much larger than the solar system, which is about 80 astronomical units across.

Surprisingly, the black hole is offset by 20 light-years from the center of the disk. Furthermore, it's not at the exact center of the galaxy. Astronomers aren't sure what could have moved such a massive black hole, but one possibility is that material spilling onto the black hole creates a rocket-like effect. Huge radio jets have been observed emanating from NGC 4261's core. Perhaps the jets act like the exhaust of a rocket, pushing the black hole around.

The new Hubble image also shows that the disk is extremely dusty and contains enough material to make 100,000 Suns. This was unexpected, because most elliptical galaxies have very little dust. Ford and Ferrarese think the disk might be the remains of a smaller galaxy that fell

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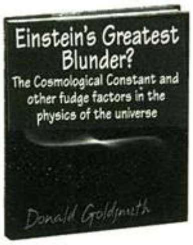
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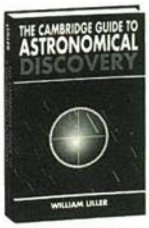
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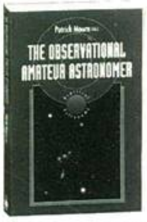
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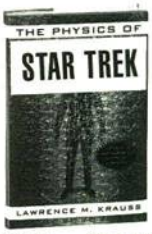
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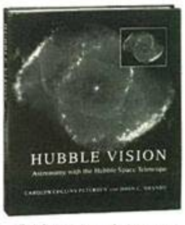
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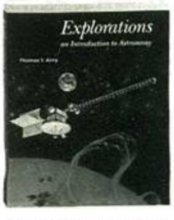
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Astronomy 5/96

into the core of NGC 4261. As the black hole gobbles up the disk material over the next 100 million years, it should produce a fireworks display that will put any 4th of July celebration to shame.

Walls Around the Sun

A gigantic wall of hot, compressed hydrogen gas surrounds the Sun and at least two other stars, says a team of astronomers working with the Hubble Space Telescope. The wall had been predicted by theory but never before detected, says Brian Wood of the University of Colorado, one of the team. (The team presented their results at the San Antonio meeting of the American Astronomical Society in January 1996.)

The wall results when the solar wind collides supersonically with the neutral hydrogen gas blowing in the interstellar wind of the Galaxy. The astronomers believe the distance to the wall is about 150 astronomical units, or nearly four times the average distance to Pluto. (Earth orbits the Sun at 1 astronomical unit.) The two other stars whose walls have been detected are Epsilon Indi and Lambda Andromedae.

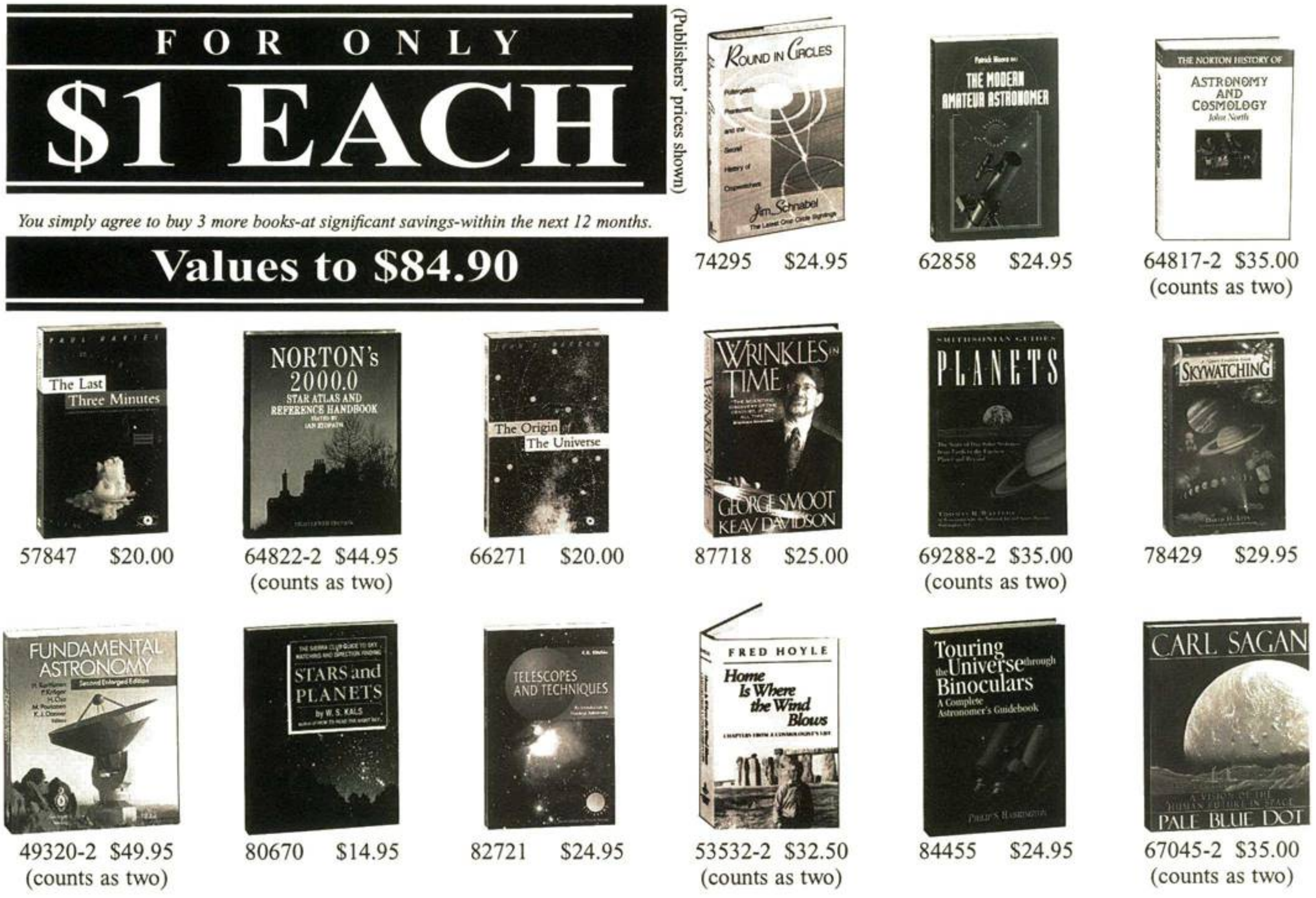
"This is the first time anyone has detected solar-like winds around other stars," says Wood, whose coworkers on the team were Jeffrey Linsky (also of Colorado) and amateur astronomer William Alexander of Huntington, West Virginia.

Another megastructure in space surrounding the Sun was studied by an astronomer at Northwestern University, Q. Daniel Wang; he also reported on it at the San Antonio AAS meeting. Wang's research, made using the Roentgen X-ray satellite and ground-based optical instruments, provides new details on the bubble of hot gas that extends roughly 500 light-years in all directions from the Sun.

"The temperature of the gas appears to vary by a factor of two," he says. This finding casts doubt on a prevailing theory that the local bubble was heated by a single supernova explosion some 200,000 years ago. Wang points to the existence of hotter and cooler clouds in the local bubble. These, he says, make it more likely that the gas emanated in stages from the local superbubble, a region in Scorpius and Centaurus where the clouds were heated by numerous individual supernovae.

A MACHO Galaxy?

When it comes to dark matter, it initially looked like the WIMPs were beating up the MACHOs. But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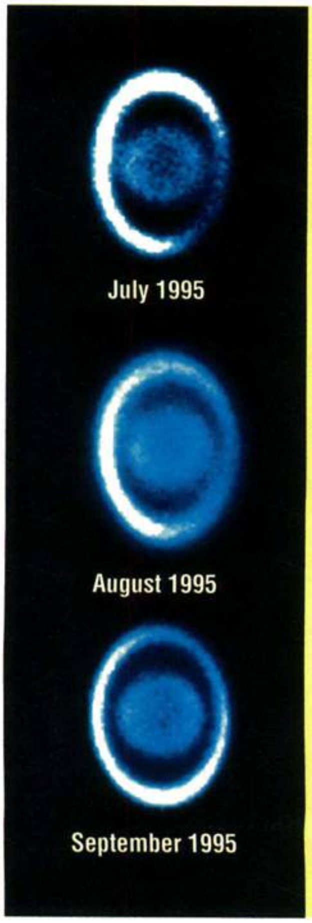
now it looks like MACHOs have the WIMPs on the ropes. At the January American Astronomical Society convention held in San Antonio, Texas, an international team of astronomers reported that roughly 50 percent of the invisible mass in the Milky Way's halo is in the form of MACHOs. If confirmed, this finding will go a long way toward solving one of the great mysteries in astronomy, the nature of dark matter.

For many years astronomers have known that at least 90 percent of the universe's mass exerts a gravitational influence on galaxies and yet emits no detectable light or radiation. The bulk of this dark matter forms enormous spheres, called halos, around the disks of galaxies like the Milky Way. Astronomers have two ideas for what dark matter could be: Either it consists of tiny particles such as neutrinos or WIMPs (Weakly Interacting Massive Particles), or it takes the form of large but dark objects called MACHOs (MAssive Compact Halo Objects), which could be black holes, neutron stars, white dwarfs, or brown dwarfs.

The team uses a phenomenon called gravitational microlensing to detect MACHOs ranging in mass from an Earth to a



NASA/JPL

ROUND AND ROUND WENT Uranus' epsilon ring, as imaged by a team of scientists from NASA's Jet Propulsion Laboratory and the University of Arizona. Led by Kevin Baines of JPL, the team used three images taken last summer and autumn at infrared wavelengths from Mauna Kea to show the ring's brightest part moving steadily around Uranus once every 264 days — the fastest precession known in the solar system. The bright region marks where ring particles lie farthest from Uranus in their orbit. Here the ring widens to 100 kilometers, five times the width it has at closest approach to Uranus. These images, plus spectra taken earlier, let Baines' team determine that the ring particles contain long-chain hydrocarbon material, not water ice or ammonia.

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The Coolest and Oldest White Dwarfs

Astronomers have detected five companion stars orbiting millisecond pulsars. Only two other similar systems are known. Previous observations suggested that some millisecond pulsars may be among the oldest objects in the Milky Way. Until now, only the upper limits to their ages were known, however. "Our optical observations of pulsar companions provide definitive evidence that some of these systems were formed when the Galaxy was much younger, five to seven billion years ago." The study is the first in a series intended to detect a large number of the oldest white dwarf stars, eventually giving important constraints on the age of the Milky Way. (See "White Dwarfs Confront the Universe," page 42, this issue.)

Carina Nebula Lays More EGGS

New evidence of cosmic EGGs — small cocoons of gas and dust surrounding newly forming stars, and known more formally as evaporating gaseous globules — has been discovered in the Eta Carina Nebula. Analysis of photos taken by the Hubble Space Telescope reveal the third and oldest, largest, and most distant grouping of EGGs known, says Reginald Dufour of Rice University. The unexpected finding indicates that star formation is taking place in a star cluster region older than other areas where astronomers have found EGGs.

Rice University

Frost on Venus?

A planetary scientist proposes that lofty highlands on Venus may be coated by a frost of the rare silvery-white nonmetallic element tellurium. Gordon Pettengill of MIT suggests this is why the highlands appear so bright in radar images. Recent analysis of Magellan radar data eliminated metals such as iron pyrite because the material is not a high conductor but more of a semiconductor. Tellurium has the right amount of conductivity and freezes out at exactly the temperature corresponding to the altitude on Venus where the edges of this bright material are seen.

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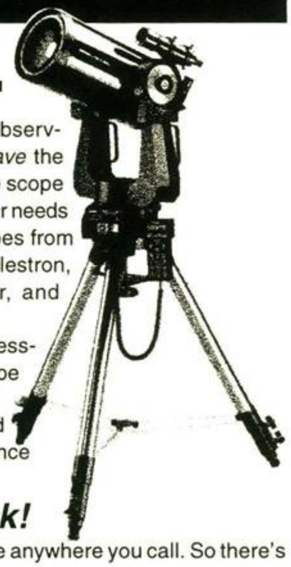

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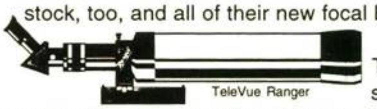

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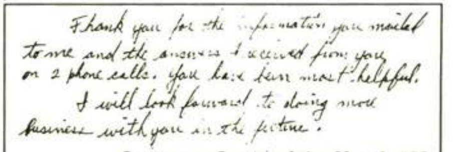

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Sun. Every night the group observes 9 million stars in the Large Magellanic Cloud (a satellite galaxy of the Milky Way) for brightenings caused when light is gravitationally amplified by an intervening MACHO in the Milky Way's halo.

The team reported seven events over the last two years. The duration of each lensing event, which lasted an average of 2 ½ months, corresponds to objects with masses between 1⁄10 and 1 solar mass. This falls in the mass range of white dwarfs, the dim, burned-out cinders of low-mass stars like the Sun that have exhausted all their nuclear fuel (see "White Dwarfs Confront the Universe," in this issue). Because these white dwarfs have not been seen directly, they are presumably very old and dark.

The simplest interpretation of the lensing events is that white dwarfs comprise about 50 percent of the halo's invisible mass. However, team-member David Bennett of the Center for Particle Astrophysics cautions, "There is some statistical uncertainty in our results, so it is possible that the objects we have discovered comprise the entire halo. It is also possible that the bulk of galactic dark matter has yet to be discovered."

At the same AAS conference, a Princeton group led by Neta Bahcall reported that the the universe contains only 20 to 30 percent of the total mass needed to bring cosmic expansion to a halt. If this result is confirmed, it means the universe is destined to expand forever. ☐

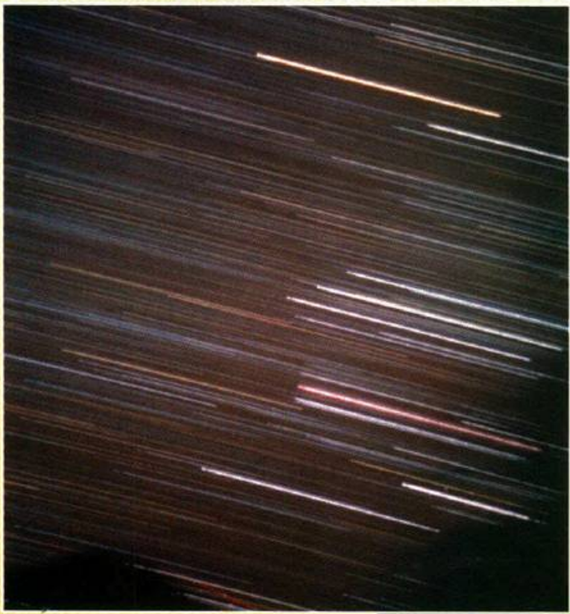
Winter Star Party Features Clear, Dark Skies

Six hundred amateur astronomers flocked to the Florida Keys last February 12–18 for the 12th Winter Star Party. The event offered an astronomical escape from the winter storms in the east and midwest, featuring clear, dark skies, a variety of large telescopes, and an array of talks from well-known astro-hobbyists. Each year the Southern Cross Astronomical Society of Miami sponsors the gathering at Camp Wesumkee between Marathon and Big Pine Key, about 35 miles northeast of Key West.

Thanks to two cold fronts that pushed down from the north, clear nighttime skies prevailed and northerners caught glimpses of the southern sky in all its glory. The bright star Canopus rose some 12° above the horizon, tickling naked-eye observers, while telescopists located in the "valley of the Dobs," a region of big reflectors on Dobsonian mounts, treasured such treats as Omega Centauri and comets Hale-Bopp (1995 O_1) and Hyakutake (1996 B_2). In the early morning hours Sagittarius and Scorpius rose some 20° higher than most northern attendees were accustomed to seeing, exposing a rich trove of southern delights.

The daytime talks featured a stellar array of astro-talent. They included presentations on 4x5 camera astrophotography by Tony Hallas, solar observing by Don Trombino, using filters for deep-sky observing by Jack Marling, planetary CCD imaging by Don Parker, deep-sky CCD imaging by Jack Newton, the Cookbook CCD camera by Richard Berry, and radio astronomy by Dave Finley. When they were not listening to talks, attendees visited the 15 displays set up by vendors who provided telescopes, accessories, and books.

Most WSPers hailed from the southeast, but others traveled from the far reaches of North America and a few from Europe. Respectable contingents arrived from Seattle, Ontario, the Netherlands, Germany, and Belgium. The next Winter Star Party is tentatively scheduled for February 3–9, 1997. — *Dan Koehler*



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ORION TRAILS OVER PALM TREES at the 1996 Winter Star Party in the Florida Keys, which featured clear southern skies. Right: The "yard scope," a 36-inch Dobsonian, opens for business with a new owner.

ASTRONOMY: Dan Koehler

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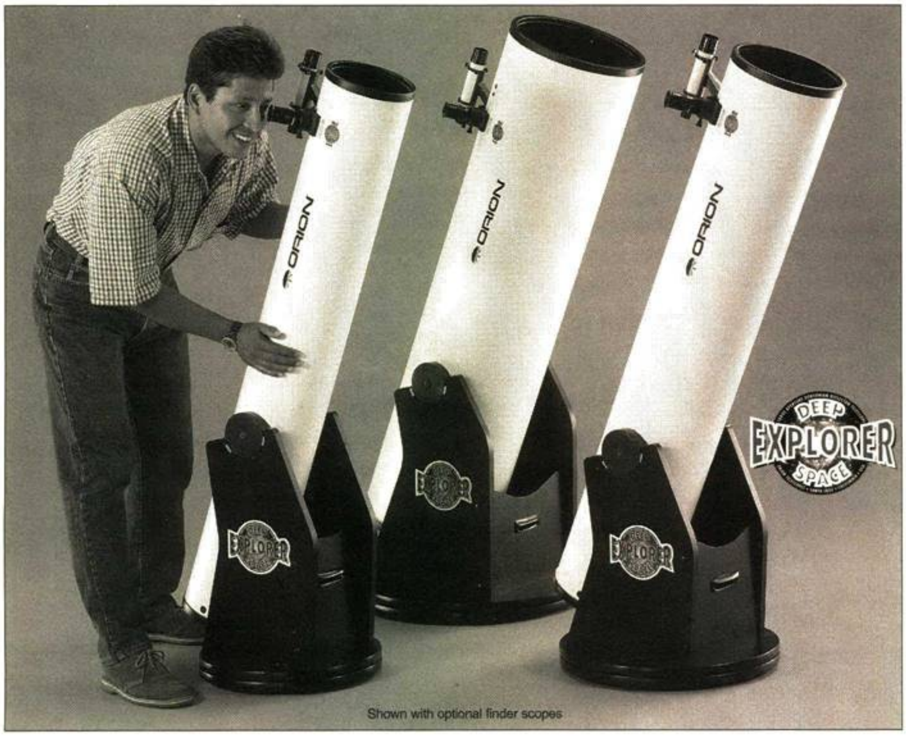

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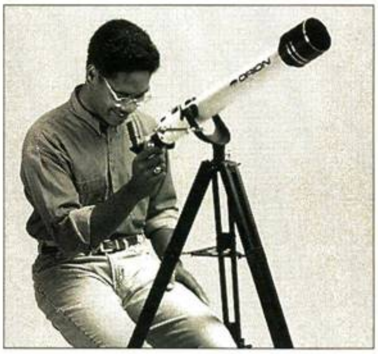

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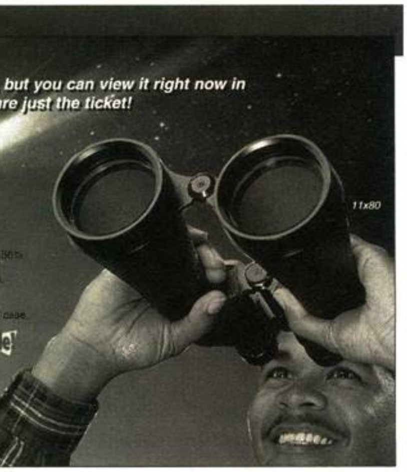

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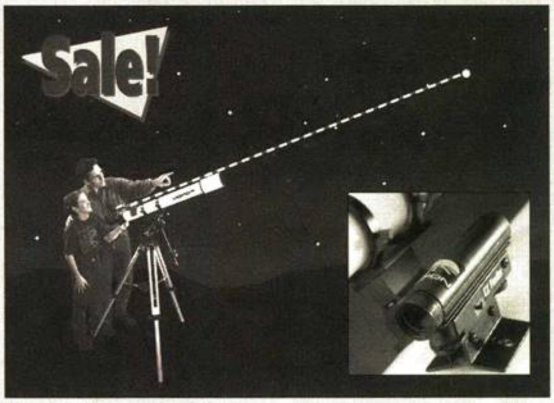

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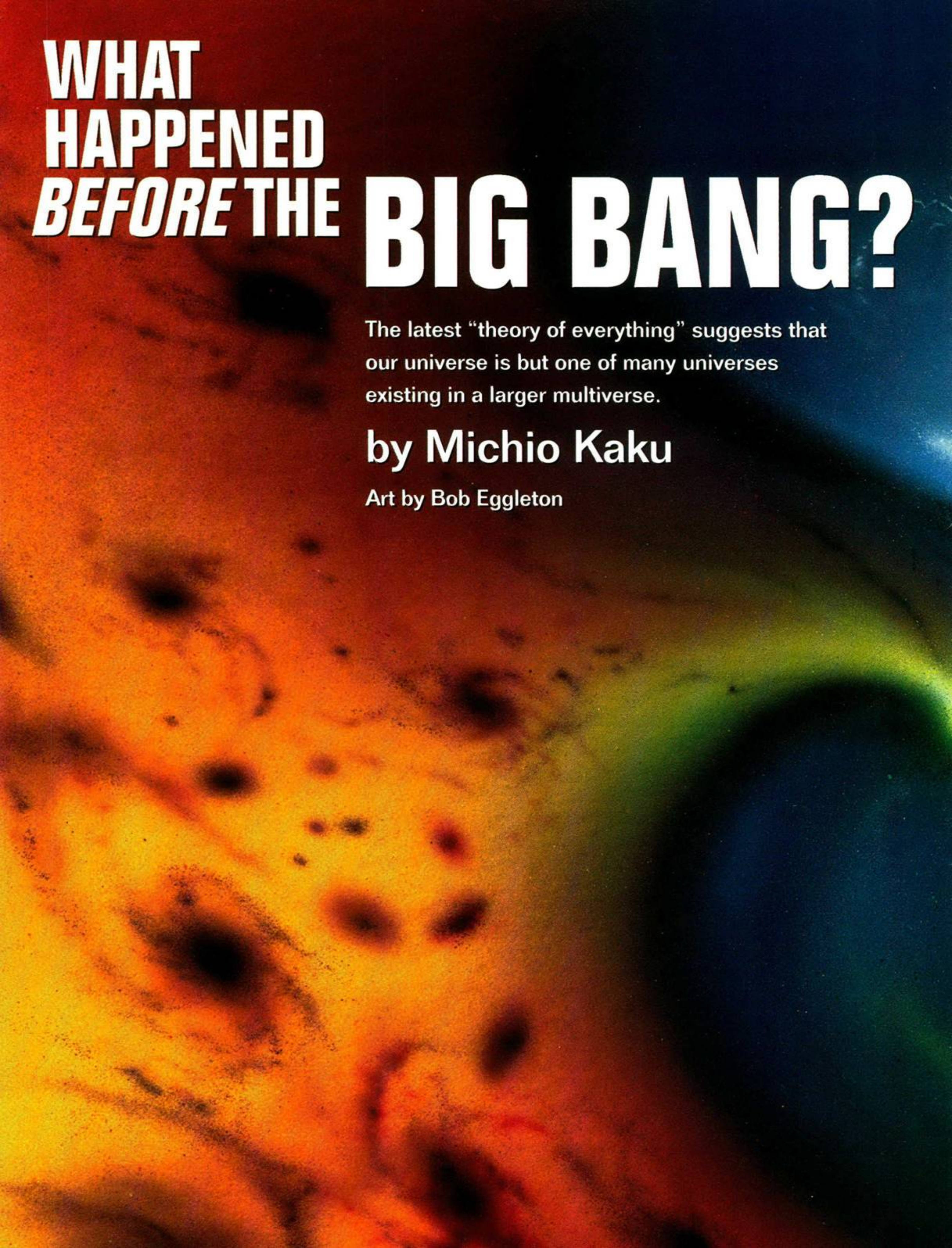
WHAT HAPPENED *BEFORE* THE BIG BANG?



The latest "theory of everything" suggests that our universe is but one of many universes existing in a larger multiverse.

by Michio Kaku

Art by Bob Eggleton

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> **“If my colleagues and I are right, we may soon be saying good-bye to the idea that our universe was a single fireball created in the big bang.” –Andrei Linde**

What’s the farthest object in the universe?

I was sometimes asked that age-old question during a 15-city lecture tour for my book, *Hyperspace*.

I pointed out that with the naked eye, one can easily see out to hundreds, or even thousands of light-years, the distance to the flickering stars making up the dazzling firmament on a clear night.

With a pair of binoculars turned on the Milky Way itself, a dim white haze becomes a brilliant sheet of stars lying tens of thousands of light-years away.

With the world’s most powerful telescopes, you can detect the very distant quasars. Because of their enormous redshifts, we estimate that they lie billions of light-years away, close to the very edge of the visible universe.

At even farther distances, we are peering into creation itself. In 1992 the COBE satellite allowed astronomers to carry out detailed measurements on the echo of creation, the 3-degree microwave radiation that uniformly fills the universe. This ancient, relic radiation, older than the stars themselves, dates back to just 300,000 years after the big bang, which took place perhaps 10 to 20 billion years ago.

Without fail, however, someone in the audience would then ask the innocent-sounding question, “But professor, what happened *before* the big bang?”

At this point, I usually detected a faint, satisfied smirk developing on the faces of a few people in the audience, as if they had finally stumped the lecturer. I knew that they expected me to throw up my hands, gaze glassy-eyed into the heavens, and sigh philosophically, “We scientists just don’t know. We don’t even have a clue. It’s one of the great unanswered mysteries of nature. Perhaps we’ll never know.”

Actually, I saw a lot of startled faces when I replied, “I’m glad you asked, because that is the subject of today’s lecture. Today, we will discuss what probably happened before creation. Analyzing this question is what I do for a living.”

A NEW SCIENCE IS BORN

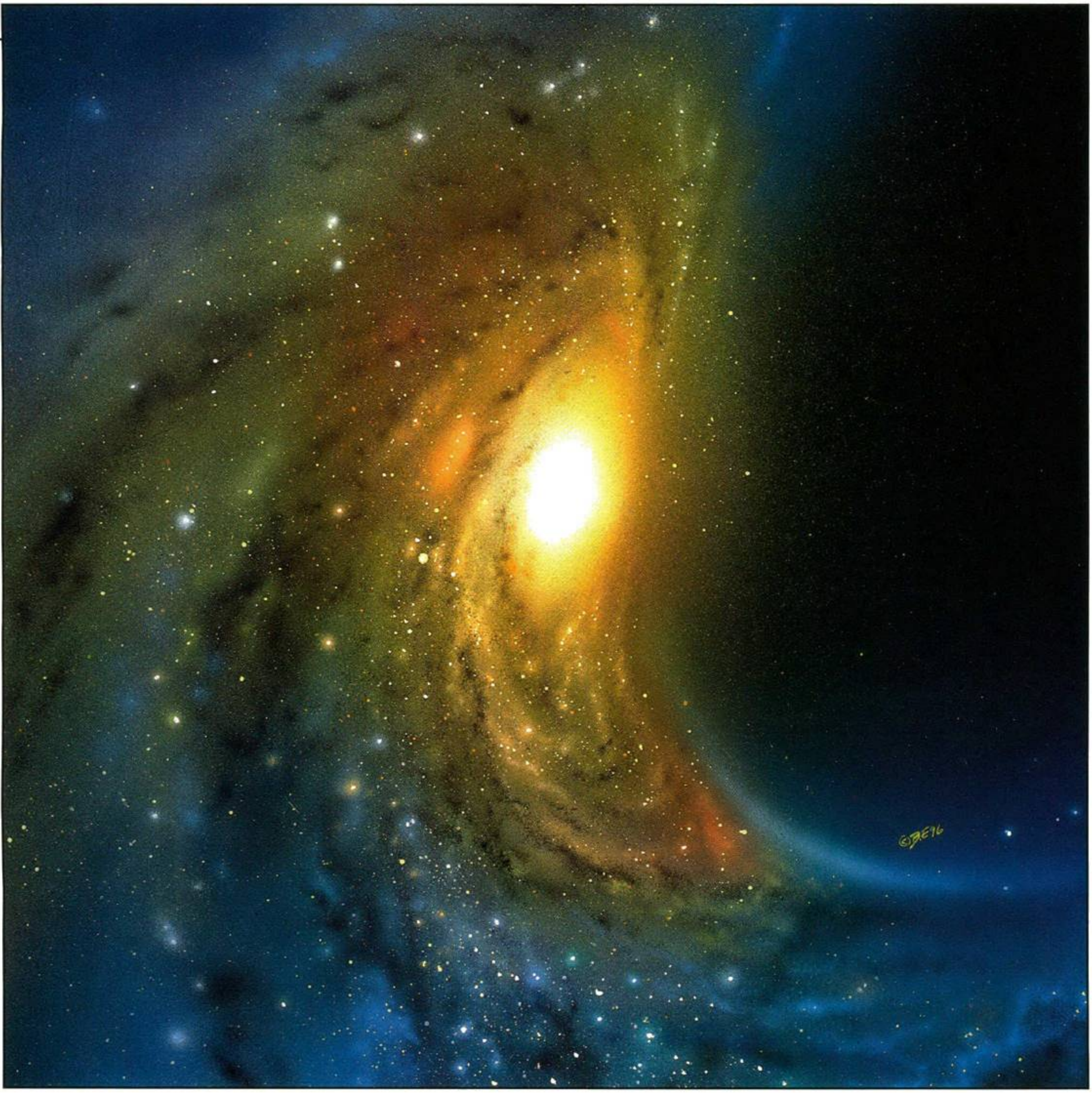
What catches them off guard is that in the leading physics laboratories around the world, the universe before the big bang has become one of the hottest areas of research. There is a tangible air of excitement as we witness the birth of a new science called quantum cosmology. Although there is no experimental proof for quantum cosmology, the theory is so compelling and beautiful that it has become the center of intense research. Already, the theory has forced us, almost against our will, to confront the bizarre possibilities of parallel universes, wormholes, and the 10th dimension. Many physicists are leaping into this game, following the lead of such pioneers as Stephen Hawking and Nobel laureate Murray Gell-Mann.

At first, “quantum cosmology” appears to be a contradiction in terms, like “jumbo shrimp.” After all, cosmology is based on Einstein’s general theory of relativity, a theory of gravity. Physicists use general relativity to describe the expanding universe, which can be compared to a smooth balloon being inflated by a child, with trillions of tiny galaxies sprinkled on the surface like star dust. By contrast, the quantum theory refers to the subatomic world, populated by thousands of strange denizens such as electrons, protons, quarks, and possibly superstrings.

Like oil and water, general relativity and the quantum theory don’t mix. For example, they take precisely opposite strategies in describing gravity. General relativity views gravity emerging from the warping of the continuous, smooth fabric of space-time, while the quantum theory sees gravity emerging by the exchange of tiny packets of energy called gravitons.

For the past 50 years a cold war has existed between general relativity and quantum theory; each theory has developed independently of the other, and each has had unparalleled success as long as it has stayed within its domain. However, the two theories must necessarily collide at the instant of the big bang, when gravitational forces and temperatures were so fierce that even particles would have been ripped apart. At these energies, Einstein’s theory becomes useless and the quantum theory takes over. Quantum effects overwhelm general relativity at a temperature of 10^{32} kelvins, which is a trillion trillion times hotter than the center of a hydrogen bomb explosion.

In other words, the secret of the big bang’s origin lies with merging the two theories into a higher one, a theory of everything that includes both theories.



Physicists need a quantum theory of gravity that simultaneously describes both the subatomic quantum world and the structure of the universe. And this shotgun marriage of general relativity and the quantum theory is spawning even more bizarre progeny, such as parallel universes and hyperspace.

PARALLEL UNIVERSES

One of the principles of quantum cosmology is that we must treat the universe just like we treat a quantum particle, and the simplest particle is the electron. As students learn in chemistry class, we never know for certain which energy level an electron occupies; quantum fluctuations are always bouncing an electron into various energy levels simultaneously. Similarly, once we treat the universe like an electron, then we are forced to conclude that the universe can exist in several different states simultaneously, i.e. parallel universes.

The simplest analogy is boiling water, which is a quantum effect. Tiny bubbles constantly form in the water and then expand very rapidly. If we treat the universe like a bubble, then we see that our universe coexists with a sea of other bubbles. Our universe, then, may be nothing but a quantum bubble, the result of a quantum fluctuation in an infinite ocean frothing with universes. In this infinite ocean, called the multiverse, the vacuum is constantly spawning new universes. In this picture, big bangs constantly take place, each representing a quantum

We have a constant genesis, or boiling of universes, in an ocean of cosmic nothing or Nirvana.

fluctuation in the vacuum.

Creating universes out of nothing may seem to violate cherished conservation principles, until we realize that it takes no energy to create a universe. If the universe is closed like a bubble, then the energy content of its matter is positive, while the energy of its gravity is negative: The sum is exactly zero (because it requires positive energy to lift an object out of a gravitational well, the object's gravitational energy is negative). Thus it takes no net energy to create new bubbles, which are constantly being created in the sea of nothing. Universes are for free.

This doesn't help if you want to create a universe in the laboratory. As Alan Guth, originator of the inflationary universe, has pointed out, you would have to heat up matter to 1,000 trillion trillion degrees to create a baby universe in your basement. (The net energy of this system, however, might still be zero, since the positive energy concentrated in your basement in turn generates a large gravitational field which surrounds the system, whose energy is negative.)

Andrei Linde of Stanford University, one of the pioneers of the inflationary universe, believes that these bubbles are constantly churning and peeling off other bubbles. In the cover article for the November 1994 issue of *Scientific American*, he wrote, "If my colleagues and I are right, we may soon be saying goodbye to the idea that our universe was a single fireball created in the big bang."

This new picture of cosmology creates a new twist on religious mythology. In theology, most myths concerning the origin of the universe fall into one of two categories: the Judeo-Christian myth of Genesis, which describes a definite instant called creation, or the Hindu-Buddhist myth of Nirvana, which describes an endless universe that has no beginning in time or space. In this new picture, we combine these two mythologies into one coherent picture: We have a constant genesis, or boiling of universes, in an ocean of cosmic nothing or Nirvana.

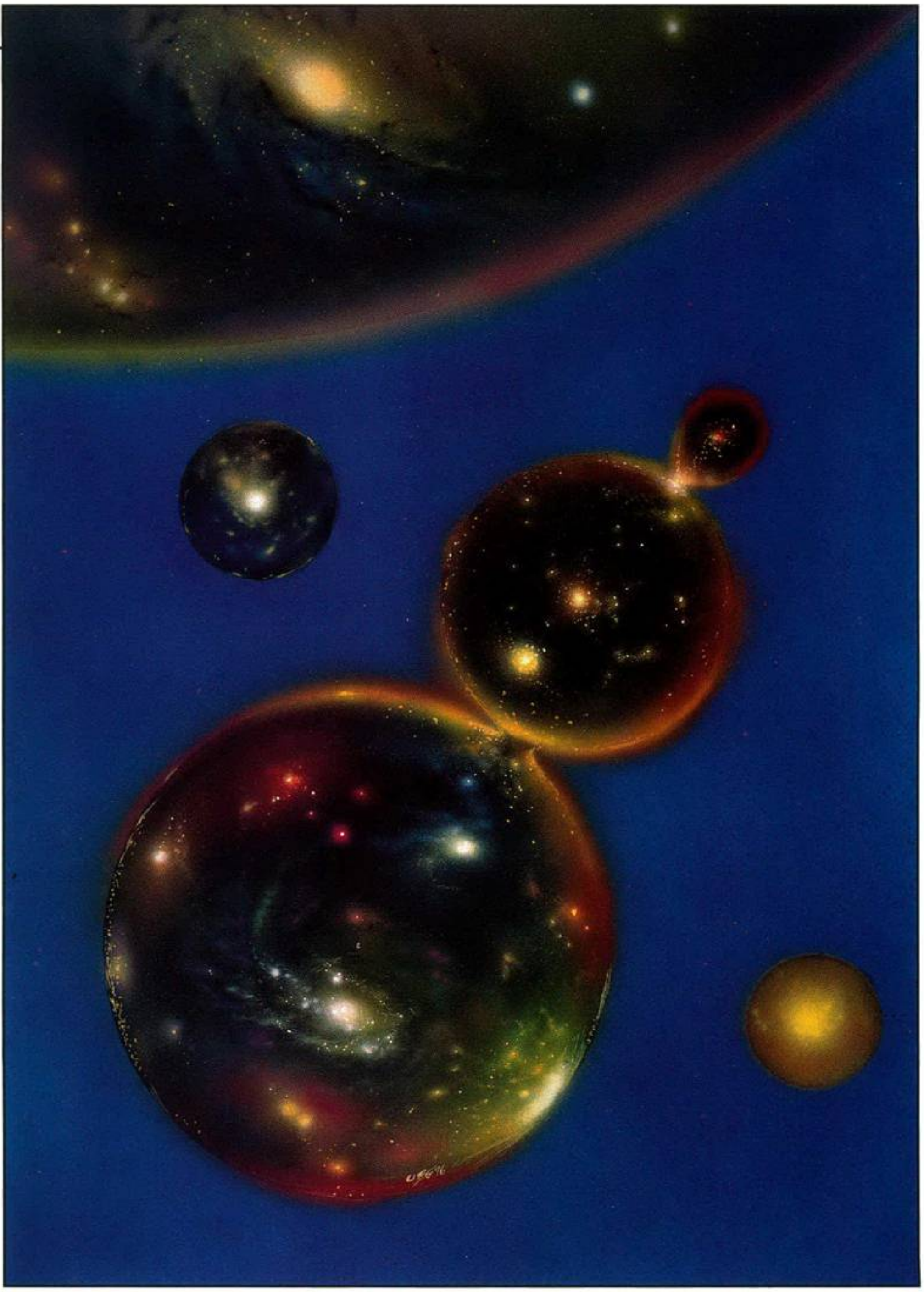
LIFE IN A PARALLEL UNIVERSE

I was once involved in a discussion with Nobel laureate Steve Weinberg. When I mentioned this picture of millions of big bangs constantly emerging from nothing, Weinberg said, "I find this an attractive picture and [it's] certainly worth thinking about very seriously. An important implication is that there wasn't a beginning; that there were increasingly larger big bangs, so that the [multiverse] goes on forever — one doesn't have to grapple with the question of it before the bang. The [multiverse] has just been here all along. I find that a very satisfying picture."

Weinberg cautioned, however, that there may not be life in these other universes. Most of them, in fact, are probably dead universes, where the proton lifetime is less than, say, 10 billion years, the minimum time necessary to create stable organic chemicals, DNA, and life itself. This is because physicists find it difficult to construct theories in which protons have lifetimes long enough to create the chemicals for life. These other universes may be lifeless seas of neutrinos, photons, and electrons, incapable of combining to form life. Our universe, in fact, may be one of the few universes that are compatible with life.

This compelling picture of creation emerging from quantum cosmology may also solve the curious puzzle of the anthropic principle. Physicists have long observed the remarkable coincidence that the fundamental constants of the universe fall within an exceedingly narrow band that is compatible with life. Is life, therefore, a special property of the universe? As Freeman Dyson of the Institute for Advanced Study has said, "It's as if the universe was expecting us." For example, if the electric charge or the gravitational constant were changed slightly, then stable DNA molecules would not be possible. The strong anthropic principle, in fact, concludes that this proves the existence of a divine entity or God.

In quantum cosmology, however, we have a simple explanation: Perhaps there are an infinite number of possible universes, with different physical constants. We just happen to live in the one that is compatible with life. That explains why we are here to discuss the question in the first place. So it is not an accident at all that the physical constants are compatible with life; we coexist with plenty of dead universes where the physical constants are incompatible with stable DNA-type molecules.



But if most of the universes are dead, this raises the ticklish question of whether some of the universes might look just like ours. Some of them, in fact, may be carbon copies of our own universe, except with a tiny quantum twist.

There is the story of a Russian physicist visiting the United States for the first time, asking to be taken to Las Vegas. Considering him to be a seasoned gambler, his American hosts were curious to learn what his gambling strategy might be. The Russian said that he would put all his money, every penny, on the first bet. But, his hosts protested, "That's a ridiculous strategy." "Yes," he replied, "but in one parallel universe, I shall be rich beyond my wildest imagination!"

Strange, but perhaps true. In millions of other universes, however, he will be broke.

This raises another delicate question: Can we visit these parallel universes? Can we walk down Main Street one day, only to find a hole in space emerging in front of us, leading us to another dimension or universe, like some episode of the *Twilight Zone*? Or can we wake up one morning finding ourselves in a world where our loved ones never heard of us?

This is not an idle question; Stephen Hawking visualizes our universe as being connected by a vast, infinite network of invisible threads with all the other bubble universes. This web connecting these universes consists of wormholes, which are tunnels or gateways in space itself (see "Of Wormholes, Time Machines, and Paradoxes," February 1996).

So in principle, the answer is yes, wormholes connect our universe with others. But don't worry about falling into one. After performing a rough back-of-the-envelope estimate of the probability of such an event, I found that it won't happen within the lifetime of the known universe.

THE 10TH DIMENSION

An important defect remains, however, in this picture. Once we try to mathematically calculate the quantum fluctuations that give rise to new universes, the answer blows up, in other words, the theory becomes meaningless. Simply splicing Einstein's general theory of relativity with the quantum theory is too crude. The problem of constructing a true, rigorous quantum theory of gravity — a unification of quantum theory with general relativity — has frustrated the finest minds of the 20th century, including Einstein.

Once, Nobel laureate Wolfgang Pauli presented his

Can a hole in space emerge in front of us, leading us to another dimension or universe, like some episode of the *Twilight Zone* ?

proposal for a theory of everything while Niels Bohr was in the audience. Bohr was not impressed. He raised his hand and said, "We in the audience are all agreed that your theory is crazy. But what divides us is whether your theory is crazy enough."

All the sane proposals for a theory of everything have been shown to be mathematically inconsistent. We are forced, in fact, to go to a higher theory, which unifies both general relativity and the quantum theory into a coherent whole. At present, the only (I repeat: only) candidate for a theory of everything is the superstring theory.

Superstring theory is certainly crazy enough. It postulates that the particles we see in the universe, including the atoms in our bodies, are composed of tiny, vibrating strings. The resonances or "notes" of the strings determine the particle zoo (electrons, quarks, photons, etc.). The universe is a symphony of vibrating strings, and the laws of harmony are the known laws of physics.

Einstein once asked the question, "Did God have any choice in making the universe?" Apparently not. The principles of general relativity and the quantum theory are so alien to each other that any theory that melds them into a coherent whole must not only have enormous power, it must also be highly constrained. A theory of everything must reproduce Einstein's theory of gravity at large distances, it must reproduce the quantum theory of particles at small distances, and it must be (we believe) conceptually simple. These conditions are so stringent that there may be only one solution to them.

What is surprising, however, is that superstring theory is so constrained that it fixes the dimension of space and time to be 10. The unique feature of superstring theory is that these tiny strings (about 100 billion billion times smaller than a proton) can only vibrate in 10-dimensional space-time.

Mystics, philosophers, and science-fiction writers have always been fascinated by higher dimensions. But we now have a mathematical reason for believing in 10-dimensional space-time, for it is only in a 10-dimensional universe that we have enough room to accommodate both the quantum theory and Einstein's theory. (If we write superstring theories in, say, 12 or 13 dimensions, the theory becomes mathematically inconsistent. A universe starting out in these dimensions is apparently unstable and will decay to 10 dimensions.)

This gives us a startling new picture of quantum cosmology. These bubble universes are actually 10-dimensional bubbles, but they are unstable. Our bubble, soon after its creation, fissioned in half, into four- and six-dimensional universes. The six-dimensional universe collapsed, these dimensions are so curled up (they are 10 trillion trillion times smaller than an atom) that we can't see them. But the collapse of the six-dimensional universe allowed our four-dimensional universe to expand, giving us the expanding universe that we see today. The expanding universe is a byproduct of a much more cataclysmic event, the shattering of 10-dimensional space-time.

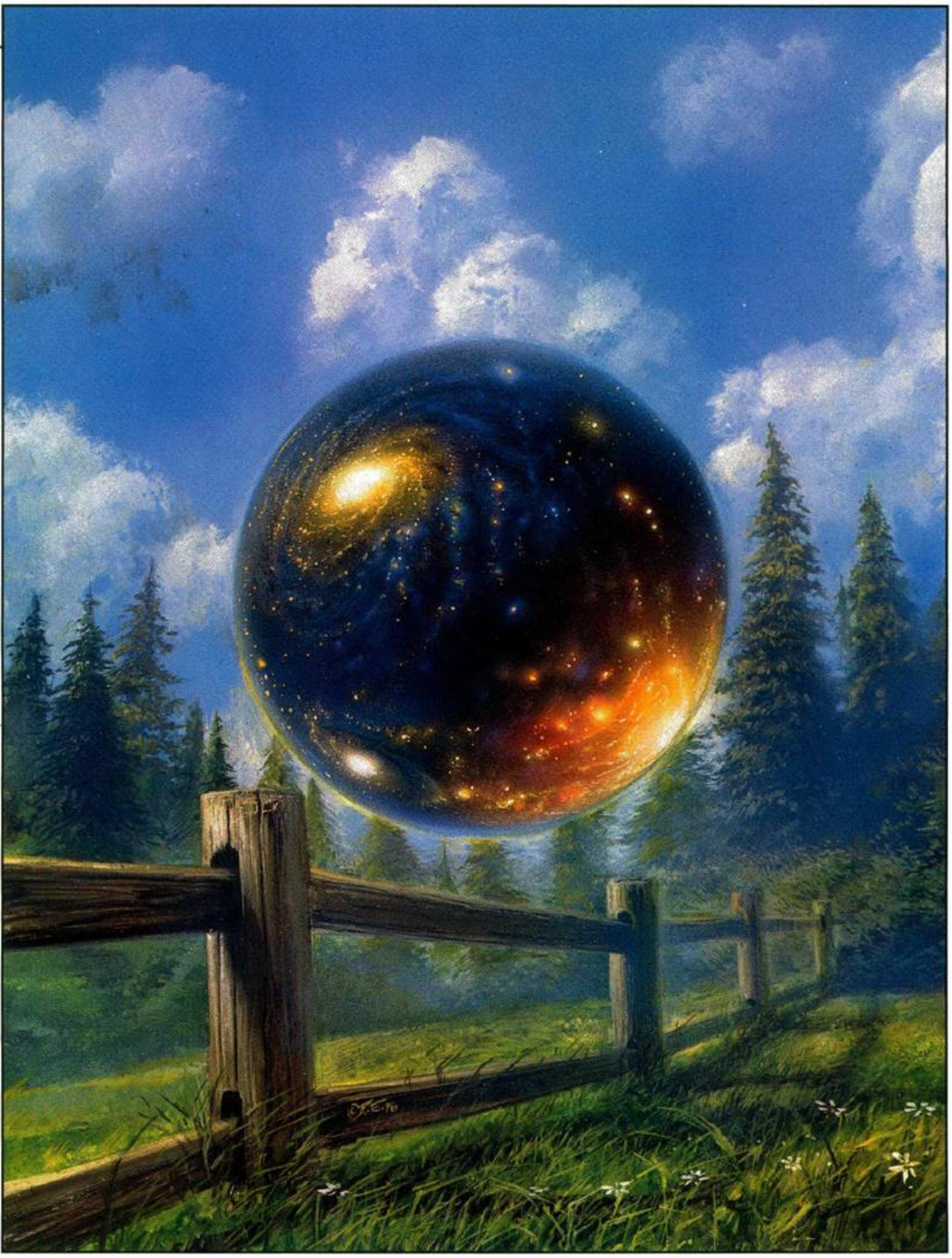
This also means that bubbles might exist that fission into 5, 6, 7, 8, or 9 dimensions. However, one can show that these bubbles are probably not compatible with life. Physics tells us that stable solar systems, atoms, and protons can probably exist only in our four-dimensional universe. Our universe is probably four-dimensional because if it weren't, we wouldn't be here to debate the question in the first place.

TESTING THE UNTESTABLE

There is a fundamental difference between religious mythology and quantum cosmology. Mythology makes no pretense of being scientific; it fails the test of being falsifiable, there is no experiment that can rigorously exclude the possibility of miracles, angels, and the like, which are not (by definition) reproducible. Quantum cosmology, however, may eventually be verified or falsified. But we do not have to wait until we fall into a parallel universe to test these ideas.

For example, the COBE satellite detected tiny ripples in the otherwise uniform microwave background radiation. This is significant, because these ripples most likely correspond to quantum fluctuations that existed at the instant of the big bang. We are, in fact, children of these ripples. The quantum fluctuations at the beginning of time gradually grew in size over billions of years, becoming the galaxies, stars, and planets that we see today.

Other tests of this scenario may come from dark matter. Numerous observations have verified the existence of a mysterious, invisible form of matter that makes up perhaps 90 percent of the mass of the universe. For example, our own galaxy cluster, the Local Group, would have disintegrated billions of years ago if it weren't held together by enormous quantities of unseen matter. One of the leading candidates for dark matter is a new form of matter called sparticles (short for super particles), which are some of the lowest frequency vibrations of the superstring. Early in the next century, we should be able to identify the precise nature of dark matter, which in turn should verify or rule out many of the conjectures in superstring theory and quantum cosmology.



Looking further ahead, we may one day even detect a new form of relic radiation left over from the big bang, the neutrino background (see "Curtains at the Edge of the Universe," November 1995). If this notoriously elusive radiation can be detected, then we will have a snapshot of the universe when it was only 3 seconds old. Then ripples on the neutrino background will give us a breathtaking look into the cosmic fireball itself, when quantum fluctuations created by the superstring were the dominant forces shaping cosmic expansion.

The next century should be an exciting one as astrophysicists probe the nature of dark matter and the microwave and neutrino background. What they find will tell us much about the first instant of creation and perhaps confirm the existence of other universes.

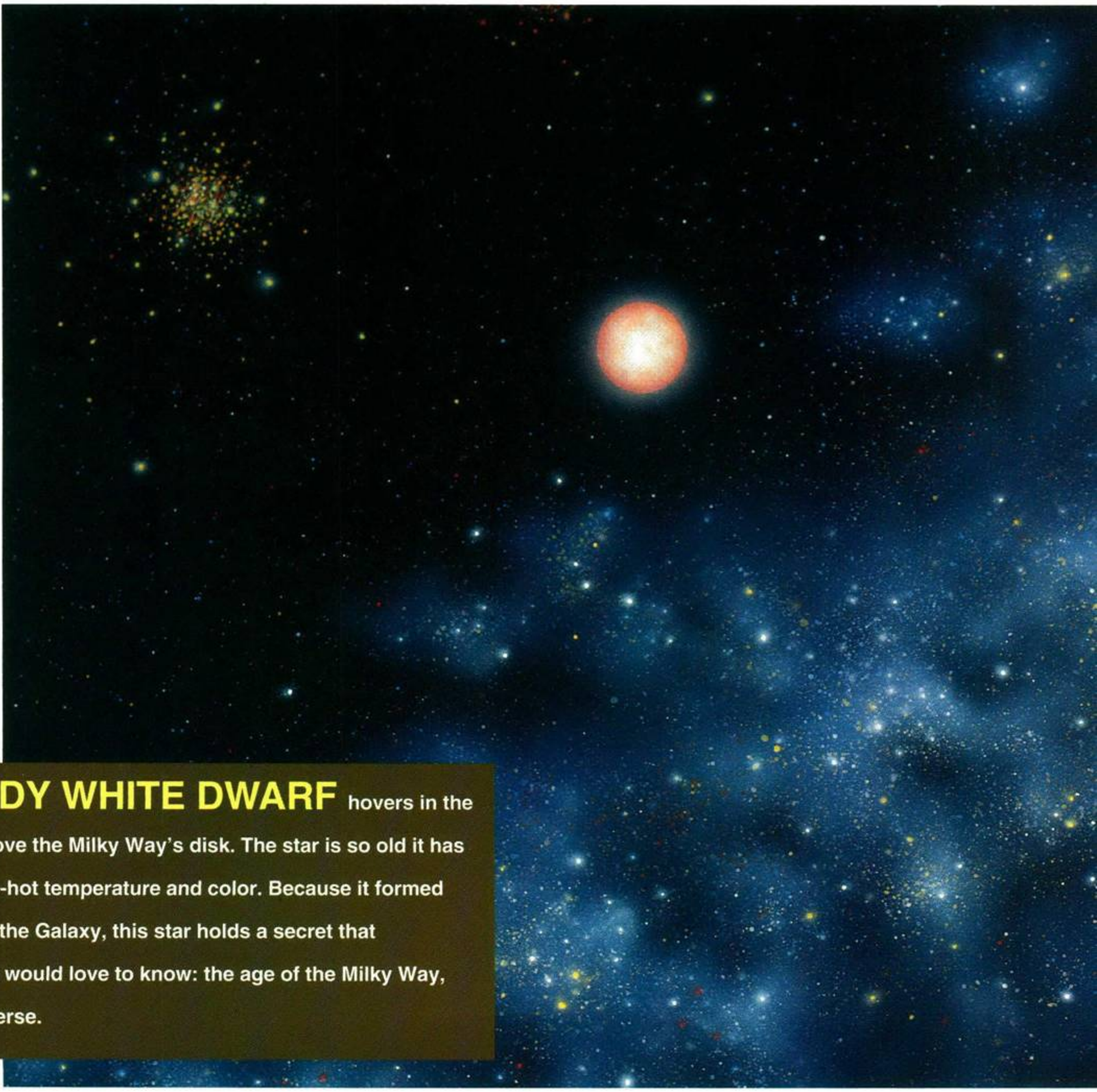
So what's the farthest object in the multiverse? Probably something floating in a bubble-universe and dimension far, far away. As the British philosopher J. B. S. Haldane once said, "The universe is not only queerer than we suppose, but queerer than we *can* suppose." □

Michio Kaku (MKAKU@aol.com) is professor of theoretical physics at the City University of New York. He is the cofounder of string field theory, and he is the author of the bestseller Hyperspace: A Scientific Odyssey Through Parallel Universes, Time Warps, and the 10th Dimension *(Oxford University Press/Anchor Books), 1994.*

White Dwarfs Confront the Universe

How old is the universe? Astronomers think that stars the size of Earth may someday give them the answer.

by Ken Croswell



LYNETTE COOK

A RUDDY WHITE DWARF hovers in the halo well above the Milky Way's disk. The star is so old it has lost its white-hot temperature and color. Because it formed shortly after the Galaxy, this star holds a secret that astronomers would love to know: the age of the Milky Way, and the universe.

White dwarf stars just don't get the press they used to. Science writers once dazzled readers with claims that, because of their great density, a spoonful of white-dwarf matter would weigh over a ton. But after the discovery of more exotic objects — like quasars, pulsars, and black holes — white dwarfs faded from popular view, and today statements about their extraordinary nature seem almost quaint.

Recently, though, these forgotten suns have entered headlong into the greatest drama in modern cosmology, the battle over the age of the universe. The coolest and faintest white dwarfs are some of the oldest stars known, so their age puts a lower limit on the age of the universe. In 1995, astronomers in Chile reported the dimmest white dwarf ever seen, and new searches will soon turn up faint white dwarfs that belong to the Galaxy's halo, the ancient population of stars surrounding the Milky Way's disk.

"The next five years are going to be incredibly exciting," says Don Winget at the University of Texas at Austin. "These stars have much to tell us about the evolution of the Galaxy and the origin of the universe."

Fading Suns in an Expanding Universe

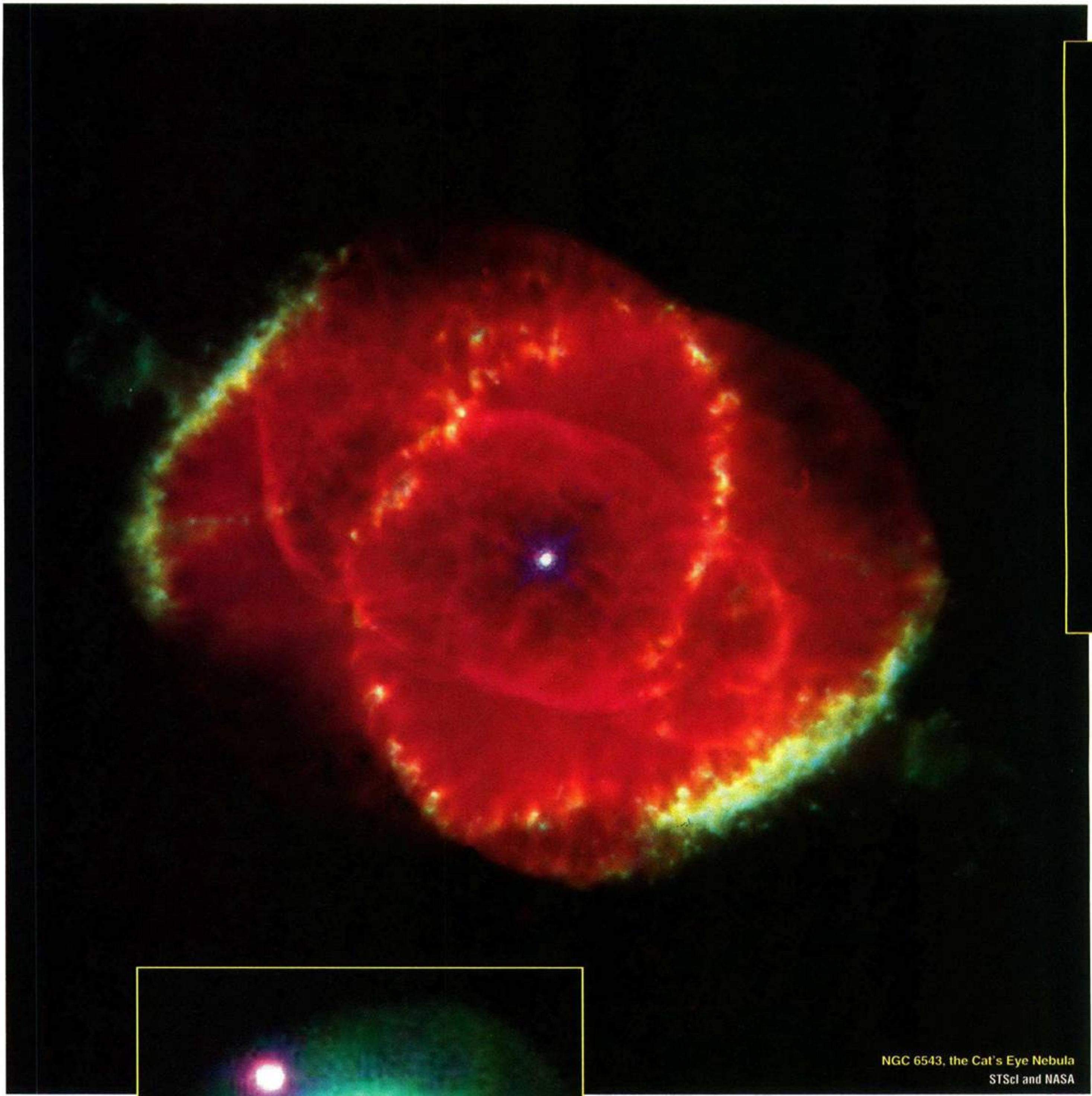
The fight over the age of the universe is as large as white dwarfs are small. Recent measurements suggest the universe is expanding so fast that it has taken only 8 to 11 billion years to reach its present size (see "A Milestone in Fornax," October 1995). Impossibly, that makes the universe younger than the Milky Way's halo, whose stars are thought to be 15 billion years old. This number comes from calculations of how main-sequence stars like the Sun evolve as they fuse hydrogen into helium and then expand into red giants at the ends of their lives.

"Main-sequence evolutionary calculations have been so enormously successful in explaining the H-R diagram that we sometimes forget how incredibly difficult the calculations really are," says Winget. He notes that main-sequence ages depend on uncertain nuclear reaction rates and the treatment of energy transport in stars. "From a theorist's point of view, white dwarf stars are quite a bit simpler," says Winget. "As University of Illinois stellar evolution expert Icko Iben once remarked, 'Any fool can make a white dwarf.'"

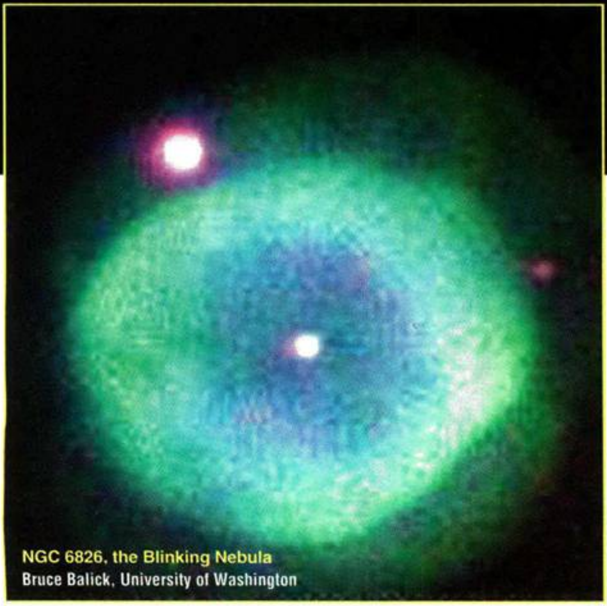
White dwarfs are much fainter than bright main-sequence stars and red giants, making these diminutive objects so hard to see that not a single one is visible to the naked eye. Yet white dwarfs account for one in ten stars. The two nearest white dwarfs — Sirius B and Procyon B — are less than a dozen light-years from the Sun.

A typical white dwarf is a little larger than Earth but has 60 percent the mass of the Sun. It forms after a star that is born with less than eight times the Sun's mass expands into a red giant. The red giant eventually casts off its atmosphere, exposing the hot, dense core — the white dwarf.

A white dwarf does not burn nuclear fuel, as the Sun and other stars do; instead, it shines because it is hot. Since white dwarfs no longer generate energy, their evolution resembles the fading fortunes these stars have faced during the 20th century: They start off



NGC 6543, the Cat's Eye Nebula
STScI and NASA



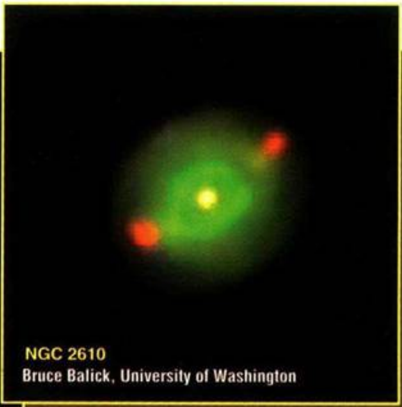
NGC 6826, the Blinking Nebula
Bruce Balick, University of Washington

hot and bright but soon cool and fade. Thus, despite their name, white dwarfs come in all colors. The hottest and youngest are blue or white, whereas cooler and older white dwarfs are yellow, orange, or even red. This steady cooling from blue to red makes it relatively easy to calculate a white dwarf's age.

"The white dwarf method gets you away from all the annoying problems that plague other age determinations and substitutes a few of its own instead," says Jim Liebert of the University of Arizona.

Early in its life, when the white dwarf is hot and blue, its temperature may be over 100,000 kelvins — some 20 times hotter than the Sun. At first, the dying star loses energy through an exotic nuclear process.

NGC 3242, the Ghost of Jupiter Nebula
Bruce Balick, University of Washington



NGC 2610
Bruce Balick, University of Washington

AT THE BEGINNING OF THE END OF THEIR LIVES white dwarfs are shrouded in the puffed-off gas that once made up their normal-star envelopes. The white dwarfs at the centers of these planetaries are young-old stars, and as such are not much help to astronomers in determining the age of the universe.

The hot, dense white dwarf interior generates neutrinos, ghostly particles that penetrate anything and readily escape into space, taking the white dwarf's heat with them.

After neutrinos cool the white dwarf to 25,000 kelvins — the temperature of Sirius B — the star stops producing many neutrinos and enters its simplest phase, when it cools and fades by emitting heat. But as the star falls to 7000 kelvins — slightly warmer than the Sun — a major complication sets in. Up to this point, the star, dense though it is, has been a gas. But at 7000 kelvins, it begins to crystallize into a solid. This crystallization releases heat, which temporarily delays the cooling, but afterward the star cools faster. The coolest white dwarfs are about 3700 kelvins, the temperature of a *red* dwarf.

The Age of the Galaxy

Because white dwarfs cool and fade as they age, the coolest and faintest should be the oldest. If astronomers could find a cutoff in white dwarf luminosities below which no white dwarfs existed, they could estimate the age of the Galaxy's disk, the population to which most white dwarfs belong.

Unfortunately, though old white dwarfs are numerous, they are the hardest white dwarfs to detect, both because they are dim and because their colors match those of orange and red dwarfs, the most common types of stars in the Galaxy. During the early 1970s, astronomers reported that they had found a luminosity cutoff in the white dwarf sequence. But the reported cutoff turned out to be wrong, because the observations had missed the faintest and hardest-to-see white dwarfs.

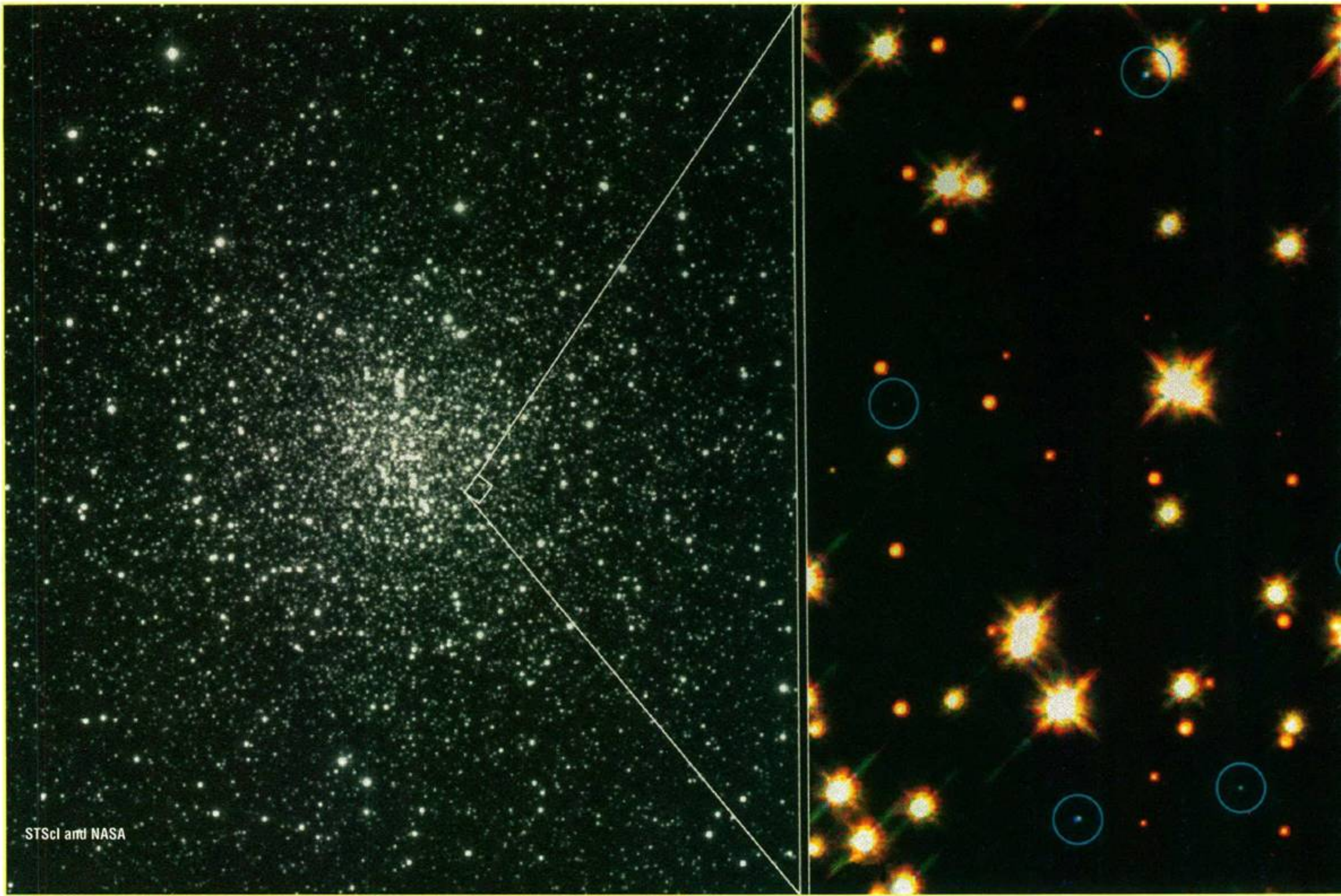
In 1979, however, Jim Liebert discovered a genuine cutoff. "The surprise was that the white dwarf sequence came to an end at an absolute visual magnitude of 16," says Liebert. "There were no white dwarf stars fainter than that. I felt then and now feel even more strongly that this cutoff is real, in part because main-sequence stars extend down past 19, and we now have hundreds of main-sequence stars fainter than 16." Liebert discovered the white dwarfs by examining faint stars that had large apparent motions across the sky, which meant the stars were nearby and thus intrinsically dim. In the same way, an automobile driver sees nearby road signs whiz by faster than distant objects. Liebert's colleague Conard Dahn, of the U. S. Naval Observatory in Flagstaff, Arizona, measured the stars' distances and brightnesses.

Liebert announced the white dwarf luminosity cutoff at a 1979 meeting in Rochester, New York. Winget was there and recalls the reaction. "Everybody said, 'Nah, Jim; you're not right. It's just another observational selection effect.'" But today most astronomers think the cutoff is real.

At the time, Winget was computing models of how white dwarf stars evolve over time, models that could convert Liebert's luminosity cutoff into an age. "I was listening to Jim talk," says Winget, "and it dawned on me: Well, we get an age — 9 or 10 billion years — that's about what the Galaxy's disk is." Strangely, though, no one took notice of this work until many years later.

Winget explains what happened. In the 1980s, a Caltech scientist who studied the solar system visited Austin, Texas. One of Winget's colleagues said, "You have an age for the solar system; we have an age for the disk of the Galaxy." The Caltech scientist said, "What? Oh my God, you need to publish this, because nobody knows about it." Winget said, "Well, we mention it all the time, but nobody seems to care." The Caltech scientist said, "Nobody reads these papers on white dwarf stars; who cares about them? You've got to write a paper and put 'Age of the Universe' on it."

In 1987, Winget, Liebert, and other white dwarf



STScI and NASA

STILL CHILLING OUT AFTER ALL THESE YEARS, the white dwarfs (inside blue circles) found in the globular cluster M4 will allow astronomers to refine predictions for the cooling rate of white dwarfs. Coupled with the search for the oldest white dwarfs, astronomers will one day be able to pin down the age of the Milky Way.

experts did just that, using the white dwarf luminosity cutoff to estimate an age for the Galaxy's disk of 9 billion years, give or take a couple billion. This age took into account the short pre-white-dwarf evolution of the stars. If the Galaxy's halo is truly 15 billion years old, then there was a substantial time lag between the formation of the halo and the formation of the disk, contradicting theories that say the disk formed rapidly after the halo.

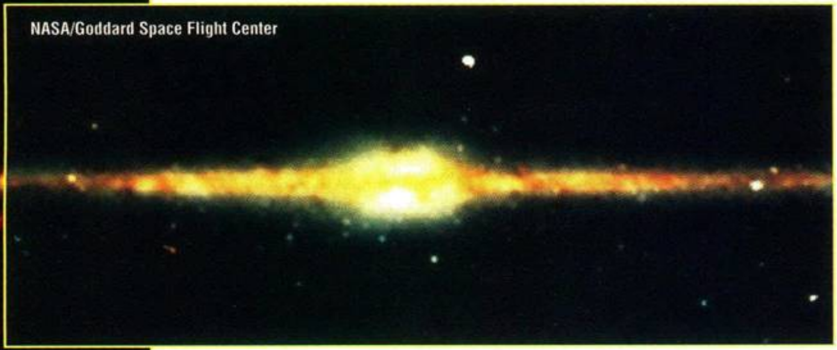
In 1995, however, María Teresa Ruiz and Marianne Takamiya of the University of Chile reported a white dwarf much fainter than any other known. The faintest white dwarf had an absolute visual magnitude of 16.3, but the new white dwarf, named ESO 439–26, has an absolute visual magnitude of 17.4, giving it only a third the brightness of the previous record holder. ESO 439–26 lies 135 light-years away in Hydra

But the new star may not change estimates of the Galactic disk's age. "That's always the problem when you have one object," says Winget. "Is it a weird duck, or is it representative? If it's a weird duck, then you can't make any conclusion about the total population of stars."

Indeed, a detailed analysis indicates that ESO 439–26 is faint, not because it is older than other white dwarfs, but because it is more massive. A massive white dwarf is actually smaller than a normal white dwarf, because the greater gravity squeezes the star to a smaller radius. Most white dwarfs are about 0.6 solar mass. But a few, such as Sirius B, are as massive as the Sun. The new work finds that ESO 439–26 is faint because it is small, since a small star radiates less light than a larger star of the same temperature. The star is 6 to 7 billion years old, so it will not alter age estimates of the Galaxy's disk.

Welcome to the Universe

Ultimately, astronomers want to use white dwarfs to determine the age of the universe. Although an age for the Galactic disk of 9 billion years tells astronomers something about the Milky Way, it does



NASA/Goddard Space Flight Center

not say much about the universe, since the disk does not comprise the Galaxy's oldest stars. Instead, astronomers need to detect a luminosity cutoff among white dwarfs in the halo.

Unfortunately, finding halo white dwarfs is not easy. "It really is a needle in a haystack," says Liebert. Like the Sun, nearly all nearby stars are members of the disk population. Although astronomers have catalogued thousands of white dwarfs, only half a dozen are known halo objects. This is not nearly enough to search for the luminosity cutoff that will reveal the halo's age.

However, Chuck Claver at Kitt Peak National Observatory is using a sensitive charge-coupled device (CCD) to search for faint white dwarfs. His survey will turn up many faint white dwarfs in both the disk and the halo. Then astronomers can compare the age of white dwarfs in the halo with the age derived from halo main-sequence stars in globular clusters. Those are the stars that give an age of about 15 billion years for the Galaxy — older than the universe, according to some recent measurements.

But Winget thinks the ages of globular clusters may be wrong. "My suspicion is that the main-sequence evolutionary ages are an overestimate," he says. "I think that's the place to look rather than trying to invent more elaborate cosmologies that can accommodate older ages. But I don't know that, and that's what we're trying to find out." Winget guesses that the Galaxy's halo is only 9 or 10 billion years old, which does not conflict with recent determinations of the universe's age. To prove that, though, he needs to show that the halo white dwarf luminosity cutoff is similar to the disk's.

"If this is correct," says Winget, "the Sun won't last quite as long as we've been advertising." The same main-sequence calculations that astronomers use to date globular clusters indicate that the Sun, now 4.6 billion years old, has a total main-sequence lifetime of 10 billion years, which means the Sun's life is not even half over. But if those calculations are wrong, the Sun's actual main-sequence lifetime may be only 7 billion years, in which case the Sun will become a red giant in just 2 or 3 billion years.

The Problems of Dating an Older Star

Liebert, though, is not comfortable making claims about the age of the universe. "In my mind, what we determined in 1987 was the age of the Galaxy's disk," he says. "It doesn't tell you anything about a time lag between the formation of the disk and the halo. It doesn't tell you anything about whether our galaxy formed early or late with respect to when other galaxies formed. And it doesn't tell you anything about how long it took galaxies to start forming after the big bang."

And Winget points out the problems with the white dwarf models themselves. "Although white dwarf evolution calculations are simpler than main-sequence calculations, they're still quite complicated," he says. For example, the estimated age depends on the temperature at which the star crystallizes, and that temperature depends on what the star is made of. White dwarfs are mostly carbon and oxygen, but the relative amount of each depends on how much carbon the core of a red giant converts into oxygen, a nuclear reaction whose rate is poorly known.

Furthermore, surrounding the carbon-oxygen core is a thin envelope of hydrogen and helium that, like a blanket, prevents the star from cooling as fast as it otherwise would, so the cooling age depends on how thick that hydrogen-helium envelope is. These and other uncertainties mean that the nominal white dwarf age of the Galaxy's disk — 9 or 10 billion years — is uncertain by at least a couple billion years, so it could be as low as 7 billion years or as great as 12 billion years. And the range could be even greater, if astronomers are underestimating the uncertainties.

In recent years, though, astronomers have used a string of telescopes around the world called the Whole Earth Telescope to scrutinize certain white dwarfs 24 hours a day. These white dwarfs pulsate, and the pulsations reveal the stars' structures, just as seismic waves disclose structures in Earth's interior. Observations of pulsating white dwarfs should reduce the uncertainties in the stars' properties. Moreover, as astronomers turn up faint halo white dwarfs, we will obtain a new, independent age for the Galaxy's oldest stellar population — an age that will impact the great controversy over the age of the universe. So maybe these faint old stars, formerly exotic and popular, will once again enter the astronomical limelight. □

Long-time contributor Ken Croswell is the author of The Alchemy of the Heavens *(Doubleday/Anchor, 1995). Its home page is http://www.ccnet.com/~galaxy/.*

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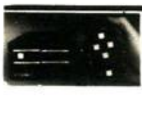

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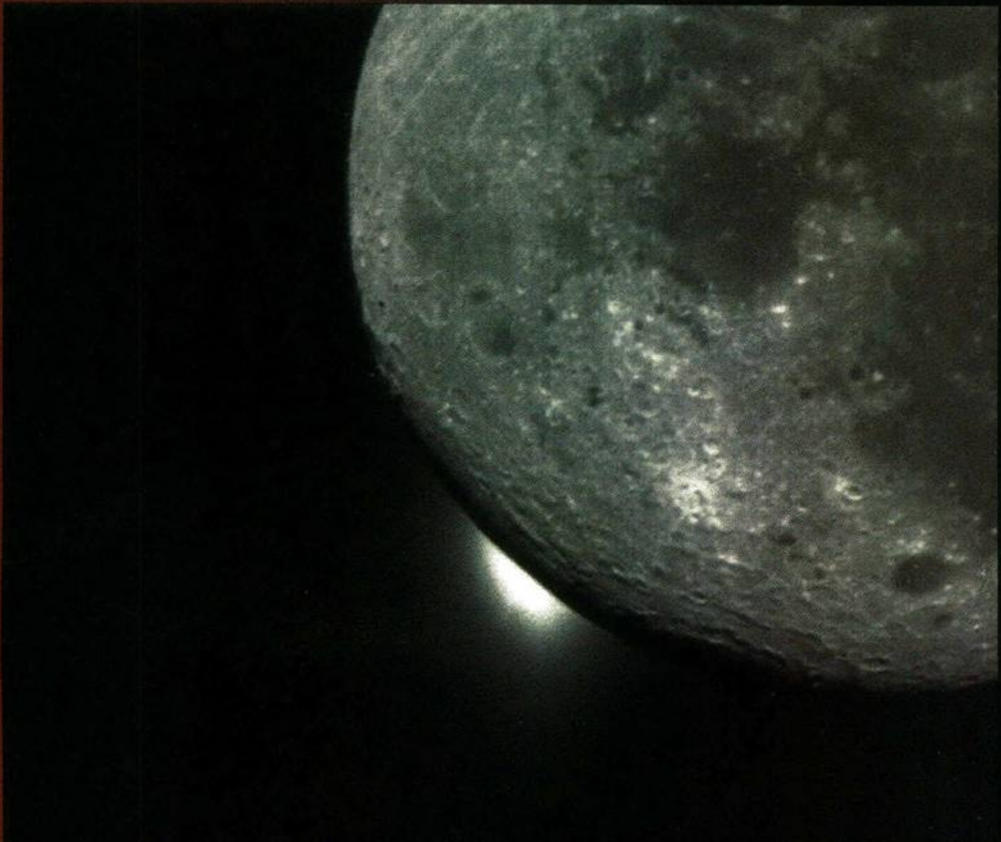
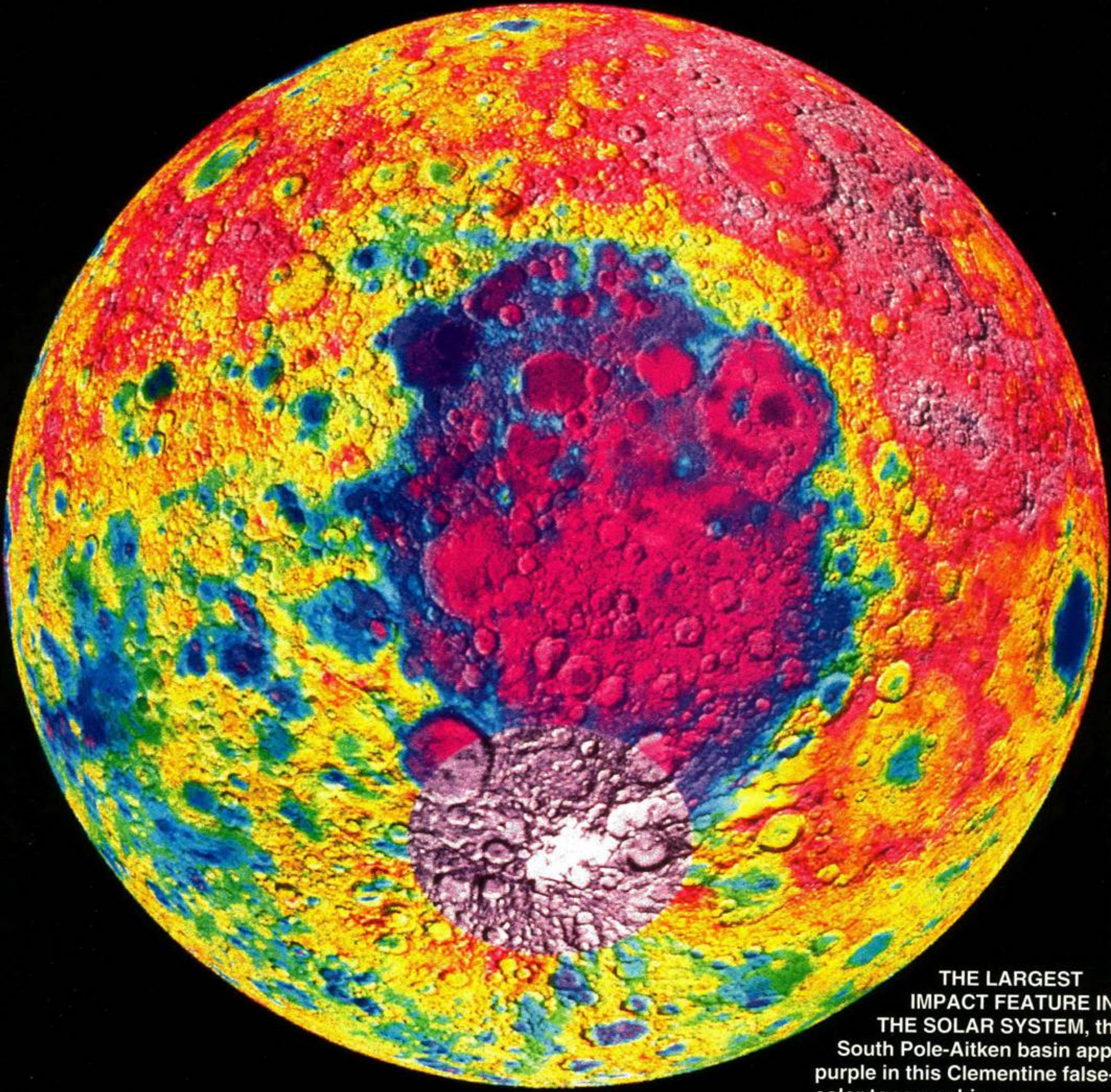
THE GIANT HOLES OF THE MOON

Ancient impact basins on the Moon, newly revealed by the Clementine spacecraft, open a window into the lunar crust and early history of the Moon.

by Paul D. Spudis



ORIENTALE BASIN graces the lunar limb as the Sun's corona peeks from behind in this image from the Clementine spacecraft. The Moon is lit by Earthshine.

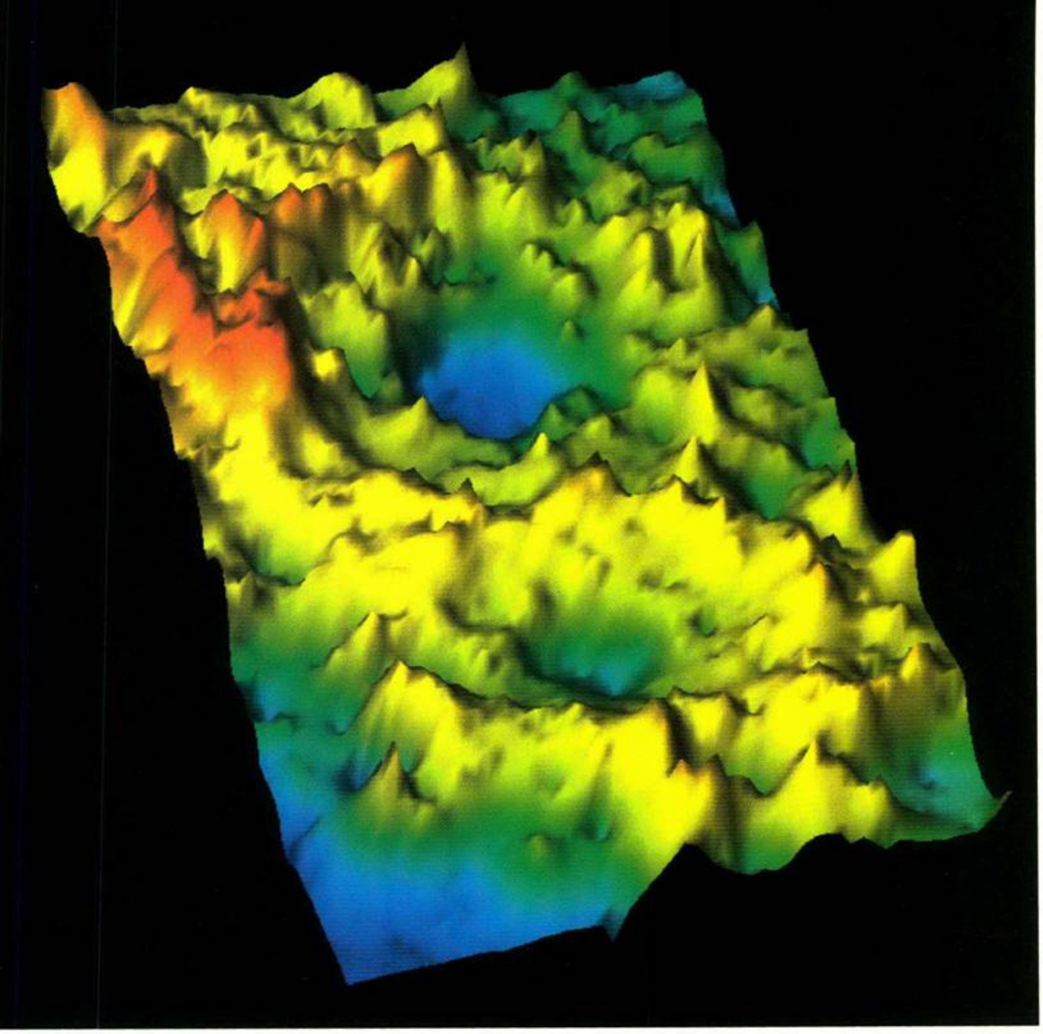


THE LARGEST IMPACT FEATURE IN THE SOLAR SYSTEM, the South Pole-Aitken basin appears purple in this Clementine false-color topographic map.

Ever since Galileo first turned his telescope on the Moon in 1609, he beheld a lunar surface covered with holes. To the astronomers of the day, this was an astonishing revelation. Most believed that the Moon and other heavenly bodies were smooth, perfect spheres. Instead of perfection, Galileo observed a scarred, jagged world, with huge mountain ranges encircling dark, smooth plains.

In 1994, the Clementine spacecraft took over 2 million images of the Moon and provided planetary scientists with a deeper understanding of the largest and most revealing holes in the Moon, so-called multi-ring impact basins. Clementine's study of these basins has shown that the Moon is lumpier than previously thought. Data from the spacecraft has created global maps of the Moon's mineralogy, uncovered new lunar features, and enabled lunar geologists to explain their nature. The mission has shed light on how lava flowed on the early Moon and

All images in this article, unless otherwise noted, are courtesy Paul D. Spudis, LPI



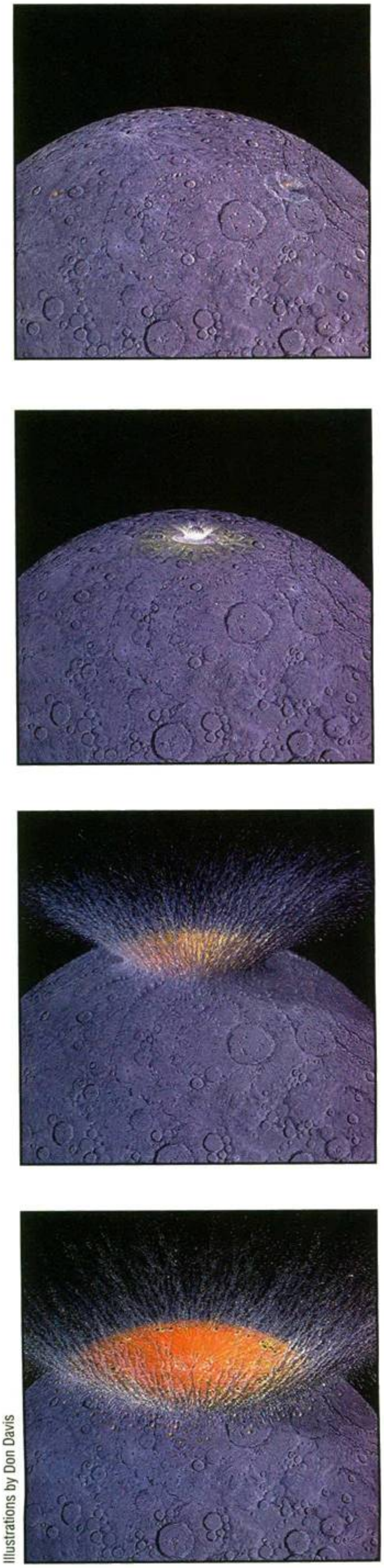
A THREE-DIMENSIONAL PLOT of the Orientale (top) and Mendel-Rydberg basins depicts physical differences between the older Mendel-Rydberg and the younger, fresher Orientale.

how rocks deeply buried in the Moon's lower crust and upper mantle were churned up by the impacts. It has also uncovered the nature of the largest impact feature in the solar system.

Multi-ring impact basins are huge impact craters, typically larger than 300 kilometers in diameter, that contain circular, concentric rings of mountains rather than central peaks found commonly in smaller craters. These basins are scattered all over the Moon and are some of its oldest features. They were created in the early days of the solar system by collisions of asteroid-sized bodies with the Moon.

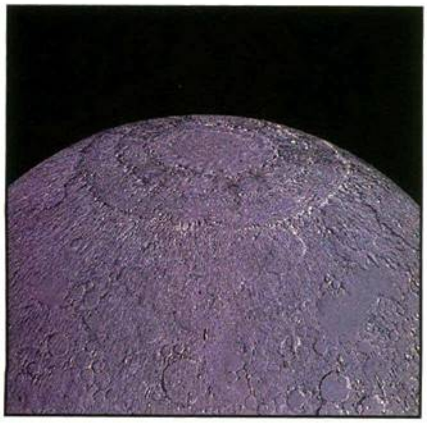
In many ways, basins create the geological framework of the Moon. The impacting bodies throw millions of cubic kilometers of material hundreds of kilometers across the face of the Moon. They dig tens of kilometers deep into the crust, bringing up rocks from great depths and exposing parts of the Moon that would otherwise be inaccessible. The basins' large, multiple rings and rims form the mountain ranges of the Moon. The basins act as large regional depressions in which lava and ejecta from other basins and craters can collect.

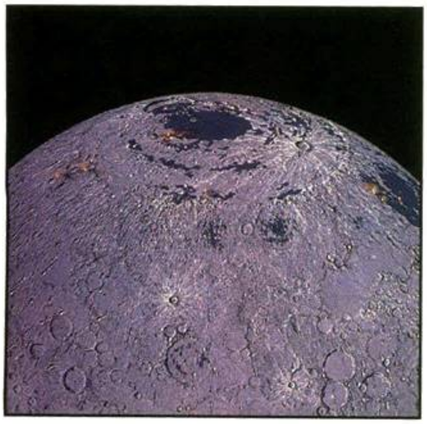
Some basins are filled by dark lava, but others are not. Many on the far side of the Moon have only a thin or partial infilling of lava.



THE IMBRIUM BASIN FORMS as an asteroid-sized body strikes the Moon 3.9 billion years ago. The 100-km body excavated a 1,200-km hole, which cooled into a basin and flooded with molten basaltic rock from 3.8 to less than 3.0 billion years ago.

Illustrations by Don Davis





Before Clementine, lunar geologists had to painstakingly map small mountains, scarps, and ridge trends to outline the rings of ancient impact basins. Clementine's mapping of the Moon identified over 40 of these features, some obvious, like the Orientale basin, and others inconspicuous to the point of near-invisibility.

Clementine has provided fresh insight into lunar basins. Perhaps the biggest surprise from Clementine came from the spacecraft's laser altimeter experiment, which measured the global shape of the Moon. (Although three of the Apollo missions carried laser altimeters, their orbits confined them to regions close to the equator.) In this experiment, a laser on the spacecraft fired pulses of light at the Moon once per second. By carefully timing how long it took for the light beam to travel from the spacecraft to the lunar surface and back again, the distance from the spacecraft to the surface could be determined precisely. From an altitude over 400 km above the Moon, Clementine scientists could determine the distance to the surface to within 50 meters, or an error of about 1 part in 10,000. The spacecraft's position was tracked by radio, so Clementine scientists knew exactly where it was at all times. Subtracting the craft's orbit from these measurements produced the elevation, or topography, of the lunar surface.

In addition to showing the global shape of the Moon, the laser altimeter has provided a new look at the basins of the Moon. The Mendel-Rydberg basin is a good case-in-point. This feature was detected by planetary scientist William K. Hartmann in 1962. As seen from Earth and in Lunar Orbiter photographs, it is an obscure feature, a vague circular area that appears relatively smooth and has a quasi-circular terrain. Before the Clementine results, the lack of topographical information prevented the sheer scale of the basin from being appreciated. When I first saw the topographic data from Clementine, I was astonished at Mendel-Rydberg. Instead of a vague indentation of the surface, the basin was almost 600 km in diameter and 5 km deep, nearly as deep as its neighbor, the obvious and very fresh Orientale basin, which measures 930 km in diameter and 7 km deep. The contrast between the old, almost invisible Mendel-Rydberg and the fresh-looking Orientale was as stark as you could get, yet their relative amounts of relief are similar.

Mendel-Rydberg was the first of a series of obscure, ancient basins revealed by Clementine. As Clementine orbited the Moon, the spacecraft confirmed and then measured the depth of one basin after another. The basin known as Coulomb-Sarton was so nearly obliterated that before Clementine lunar geologists weren't even sure how many rings it had, or even if it really existed. Yet the profiles provided by Clementine showed that this basin was indeed real. At about 500 km in diameter and 6 km deep, it is as deep as the youngest, freshest basin of its size on the Moon.

The astonishing depths of some of these obscure basins combined with information on the Moon's gravity field uncovers some important clues to lunar history. Impact craters and basins expose material from different depths within the Moon's crust. Small craters a few kilometers in size reveal the upper few hundred meters of the crust. The larger craters, such as Tycho (85 km diameter), expose material from a few to tens of kilometers' depth; such depths sample the upper to middle levels of the lunar crust. The basins, being the largest features, churn up the deepest levels of the crust. The inner rings of these large basins expose rocks from beneath the layer of impact-processed debris; lunar geologists can then look at the original structure of the pristine, intact crust. Some basins are so large they may well reveal the entire crust, exposing the upper levels of the lunar mantle for inspection.

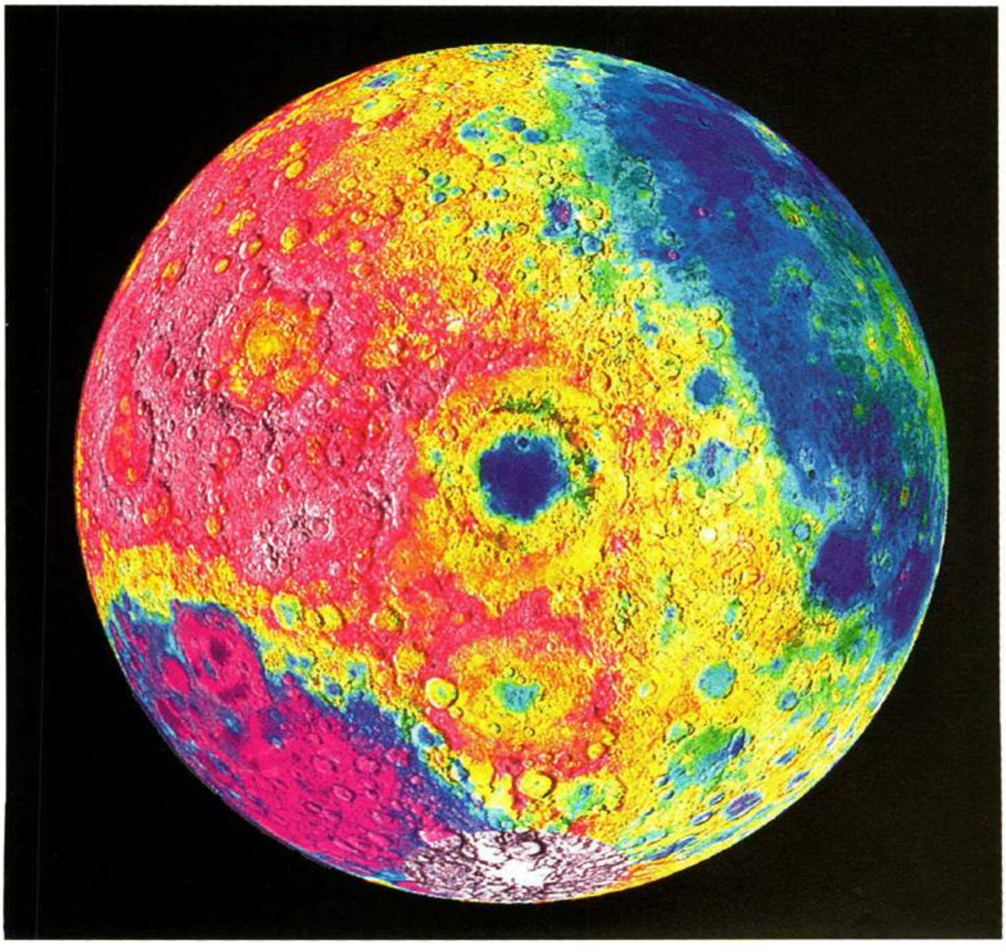
Clementine also allows scientists to look deeper into the Moon.

When a large body strikes a planet, the material blown out of the resulting hole creates a deficit of mass. This deficit shows up as a gravity anomaly. The material that has been removed to make the hole results in an area of slightly lower gravity than surrounding areas. One might expect that all of these basins would show negative gravity anomalies, as they are large holes in the lunar surface. Radio tracking data from Clementine, however, show that many — but not all — of these basins have either no gravity anomaly or even have a positive anomaly.

This reveals something about how the Moon responds to a large impact. When big impactors struck, carving out a hole and creating a basin, dense material from the mantle rose up beneath them almost immediately. This uplift occurred as millions of cubic kilometers of crustal debris were ejected. Immediately the basin stabilized, which explains why such ancient features are still preserved in such a pristine way. Early in lunar history, this upsurge did occur quickly, thus canceling the gravity anomaly. Later, as the Moon grew cooler, the rebound was only partial and incomplete. Today, a basin might have no compensation because the outer rind of the Moon is cold and stiff enough to leave the hole.

Clementine results not only have verified previously mapped basins but have uncovered new ones. The crater Crüger, east of the Orientale basin at 17° S, 68° W, lies near the center of a newly recognized large depression, almost 400 km across and about 3–4 km deep. Crüger is partly flooded with mare lava, which may have resulted from its location on the floor of this ancient basin. Why basins and lava are associated is not yet clear, but may be related to crust thinned and cracked by impacts, which allows lava to seep through onto the surface.

In another example, the eastern end of Mare Frigoris has a circular depression about 500 km across and 2 km deep. This area contains maria and high, smooth plains, and is surrounded by quasi-circular tracts of cratered terrain. These features probably indicate an ancient, nearly obliterated basin. As lunar geologists continue to examine the topographic data in detail, they will no doubt map many more impact depressions. This mapping will allow us to reconstruct the impact history of the entire Moon.

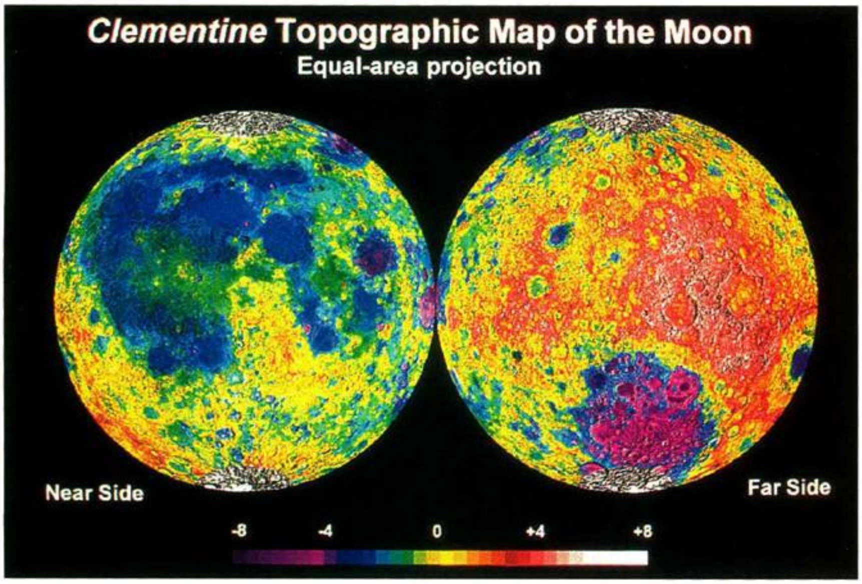


A BULLSEYE STRIKE in blue marks the Orientale basin in this Clementine false-color topographic map.

One of the most spectacular discoveries from Clementine was the revelation of the true dimension of the biggest impact crater in the solar system. Lunar geologists had known about the South Pole-Aitken basin for a long time. In his study of lunar basins, William Hartmann mapped several large mountains near the Moon's south pole and suggested that because lunar mountains are always associated with basins, a large basin probably existed on the far side. In 1968, the Soviet Zond 6 spacecraft returned stereo photographs that indicated a depression on the far side of the Moon. Careful geologic mapping had recognized huge mountains on the far side and patches of mare lava in the south-central far side highlands. These observations suggested the presence of a basin, an ancient feature over 2,000 km across.

It took Clementine's global survey to reveal this feature in all its glory. The South Pole-Aitken basin is named for two geographic features that it spans: the south pole and the 130-km-diameter crater Aitken at 16° S, 173° E. The basin has an approximate diameter of 2,500 km and, at its deepest, is over 13 km from rim crest to basin floor — more than twice as deep as earlier estimates.

Sheer size apart, lunar geologists had hints from earlier missions that the South Pole-Aitken



CLEMENTINE'S TOPO MAP of the entire Moon reveals prominent basins on the near side (in blue) that include Imbrium, Crisium, and Nectaris, all at least partly filled with mare basalt, accounting for the relative smoothness of the near side.

basin was important to the composition of the lunar surface. The Apollo 15 spacecraft found terrain just inside the rim of the basin with elevated amounts of iron and the radioactive element thorium. In 1990, the flyby of the Galileo spacecraft showed that terrain inside the South Pole-Aitken basin was strangely darker than the typical highlands. Clementine mapping has revealed that this basin contains large amounts of iron and titanium in its floor. The far side of the Moon has two major types of terrain, it turns out: the inside of the South Pole-Aitken basin and everything else.

The immense size of the South Pole-Aitken basin provides a clue as to how it may have formed. The Moon's far side crust is about 70 km thick on average, so by any reckoning, the South Pole-Aitken event must have excavated nearly the entire crust of the Moon from a large area, throwing this material across the face of the lunar globe. Just as significantly, this excavation would have exposed material buried deeply in the basin's interior, possibly including rocks from the mantle of the Moon itself.

On the basis of what lunar geologists know about the Moon from the Apollo samples, Clementine scientists suspect that the mantle of the Moon is made up of rocks very rich in magnesium and iron and contains little, if any, of the light-colored mineral plagioclase, so common in the crustal rocks. When the Clementine color data are fully analyzed, the interior of the South Pole-Aitken basin may provide a detailed picture of these rocks that make up the lower crust and upper mantle of the Moon.

The South Pole-Aitken basin may not be the only huge impact feature on the Moon. Several years ago, geochemist Peter Cadogan proposed that the near side of the Moon had another gigantic impact basin, a feature over 3,000 km across, that he named the Gargantuan basin. Astronomer Ewen Whitaker carefully mapped hundreds of features on the near side and concluded that there is indeed a giant impact basin, 3,200 km across, a feature he named Procellarum basin, after the large expanse of maria in it. The rim of this feature is roughly outlined by the western shore of Oceanus Procellarum, Gassendi, Pitatus, Sacrobosco, the eastern shore of Mare Tranquillitatis, Macrobius, Atlas, and the north shore of Mare Frigoris.

Procellarum basin has since been invoked as the explanation for many lunar things, including the localized nature of maria on the near side, the separation of rock types in the lunar highlands, and the Moon's pattern of tectonic features. Now Clementine's topographic data reveal the true nature of the Procellarum basin.

There is indeed a regional depression in the Procellarum area and the western shoreline of Oceanus Procellarum is remarkably circular. However, the basin is not well developed in its eastern and southern regions. The central highlands stand higher than the rim. Impact basins always show lower topography inside of their rim crests. The irregularity of the Procellarum rim and the elevated segments inside the rim crest show it is a depression and not an impact crater.

It is likely a coalescence of several smaller basins, a concentric pattern related to the large and prominent Imbrium basin, or some combination. It could also have an internal origin because the early Moon was extremely hot and hot bodies can form depressions from the movements of liquid rock.

Clementine's laser altimetry data have provided a new and different look at the Moon. They have revealed the extreme lumpiness of our nearest planetary neighbor, with a total topographic range of over 16 km, almost twice what had been anticipated. This wide range of relief is almost as great as that seen on the geologically different Earth and is caused almost exclusively by the presence of huge, ancient impact basins.

The detailed measurements of lunar basins returned by Clementine will allow us to better understand how they formed, how deep they are, and the structure of the underlying lunar crust.

Because these features formed on all of the terrestrial planets early in their histories, including Earth, understanding these features on the Moon will provide a better appreciation of what happens when asteroid-sized bodies smack into planets. ☐

Paul D. Spudis is a geologist at Houston's Lunar and Planetary Institute. He was deputy leader of the science team on the Clementine mission. His current research focuses on impacts and volcanism on the planets.

SKY ALMANAC

Highlights
by Alister Ling

Date	Event
4	Venus Shines at Its Brightest . . . . . (p. 56)
8	The Moon Covers Hale-Bopp . . . . (p. 63)

all month:

First Views:
The Best Asteroids of 1996 . . . .(p. 61)
Return of the Ringed Planet . . . .(p. 62)
A Tale of Two Bright Comets . . . . . .(p. 63)
Observer's Challenge:
Can You Spot Pluto's Moon? . . . . . .(p. 64)
A Red Star for Spring Nights . . . .(p. 64)

The Starry Sky:
Corvus and the Way South . . . .(p. 65)

Venus shines at its most brilliant in the evening, the two brightest asteroids of the year appear high at midnight, and the Moon passes in front of Comet Hale-Bopp on the morning of May 8.

by Jeff Kanipe

As May opens, the starry refugees of the winter sky gather in the west after sunset. Only the upper torso of Orion remains well above the horizon, while Gemini and Auriga shine as best they can through the twilight.

What really catches the eye in the west these early May evenings, however, is **Venus**, beaming like an approaching jet plane with its landing lights on. The planet reaches greatest brilliancy on May 4 when, at magnitude –4.5, it is bright enough to cast shadows on the ground or on a light-colored wall. (You'll have better luck seeing a shadow if you wait a week or so until the waning gibbous Moon exits the evening sky.)

Interestingly, Venus' greatest brilliancy nearly coincides with another circumstance, this one much rarer. The following day, Venus reaches its greatest distance north of the celestial equator for the 20th century. On that day it lies at a declination of 27°47', helping place Venus high in the sky for Northern Hemisphere viewers.

At sunset during the first half of May, Venus stands about 30° above the western horizon. By month's end, it lies only 16° east of the Sun and consequently appears quite low: about 5° high at 9 p.m. local time. It will disappear in the twilight during early June.

As long as you're in the vicinity, grab a pair of binoculars and look for **Mercury** before it passes

Venus Shines at Its Brightest

Venus hits the height of its evening-star performance on May 4. The blazing white — almost blindingly bright — planet then shines at magnitude –4.5. Watch it now because its evening show will end in June. But for the next few weeks, Venus hovers magnificently high in the western sky after darkness, setting more than three hours after sunset. The brilliant beacon gives you a chance to make some interesting observations.

First, look for a shadow cast by Venus. You'll need to wait until midmonth, when the Moon is out of the evening sky, and observe from a dark site. Place a white sheet on the ground, put yourself between the sheet and Venus, and move your hand or body back and forth. Your motion-sensitive averted vision should have little problem picking up your shadow's movement.

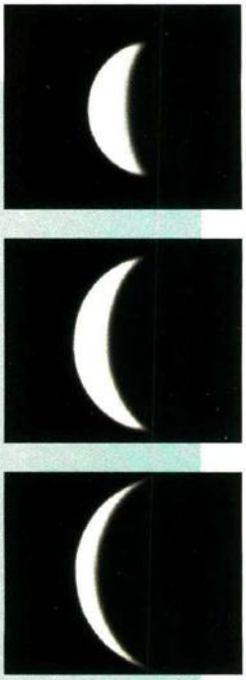
Second, use a telescope to check out Venus' rapidly thinning phase. It shrinks from 31 percent lit to 4 percent lit during the course of the month. Venus also grows in size during May, from 35" to 55" across.

How come Venus gets so bright at crescent phase? Picture Venus on the far side of the Sun. Although it is full, it's not extremely bright because it lies far away. As it approaches Earth, it grows in size and gets brighter, despite the waning phase. But after its phase dwindles to about 30 percent lit, the phase shrinks faster than the planet approaches, so Venus loses some of its brilliance.

Finally, try to spy Venus during the day, when it appears as a white pinprick in the blue sky. If your telescope has setting circles, just dial in Venus' coordinates. Or hide the Sun behind the tip of a telephone pole and note the time. Then return a certain time later (see the table), scan a little bit above the pole, and there you will find Venus. — *Alister Ling*

HOW TO LOCATE VENUS DURING DAYLIGHT

Date	Time between Sun's and Venus' passage
May 1	2h49m
May 6	2h41m
May 11	2h31m
May 16	2h16m
May 21	1h56m
May 26	1h34m
May 31	1h05m


Jean Dragesco

1996
MAY

3 Full Moon is at 7:48 a.m. EDT

4 Venus is at greatest brilliancy (magnitude –4.5), 10 a.m. EDT (page 56)
Eta Aquarid meteor shower peaks

6 The Moon is at perigee (227,752 miles from Earth), 5:45 p.m. EDT

7 The Moon passes 5° north of Jupiter, 8 p.m. EDT

8 The Moon occults Comet Hale-Bopp (page 63)
Asteroid Vesta is at opposition (page 61)

10 Last Quarter Moon is at 1:04 a.m. EDT

13 The Moon passes 3° north of Saturn, 9 a.m. EDT

14 Mercury is in inferior conjunction, 9 p.m. EDT

15 The Moon passes 1.7° south of Mars, 11 p.m. EDT

17 New Moon is at 7:46 a.m. EDT

19 The Moon passes 8° south of Venus, 9 p.m. EDT

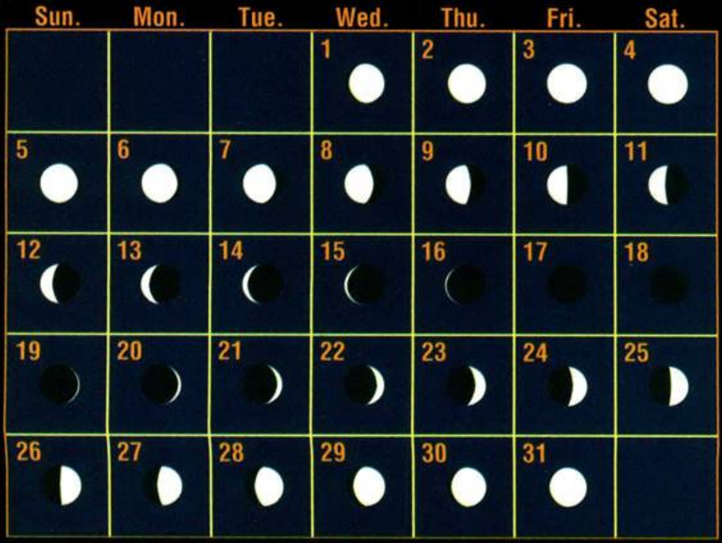
20 Asteroid Parthenope is at opposition

22 Pluto is at opposition, 10 a.m. EDT
The Moon is at apogee (251,700 miles from Earth), 12:20 p.m. EDT

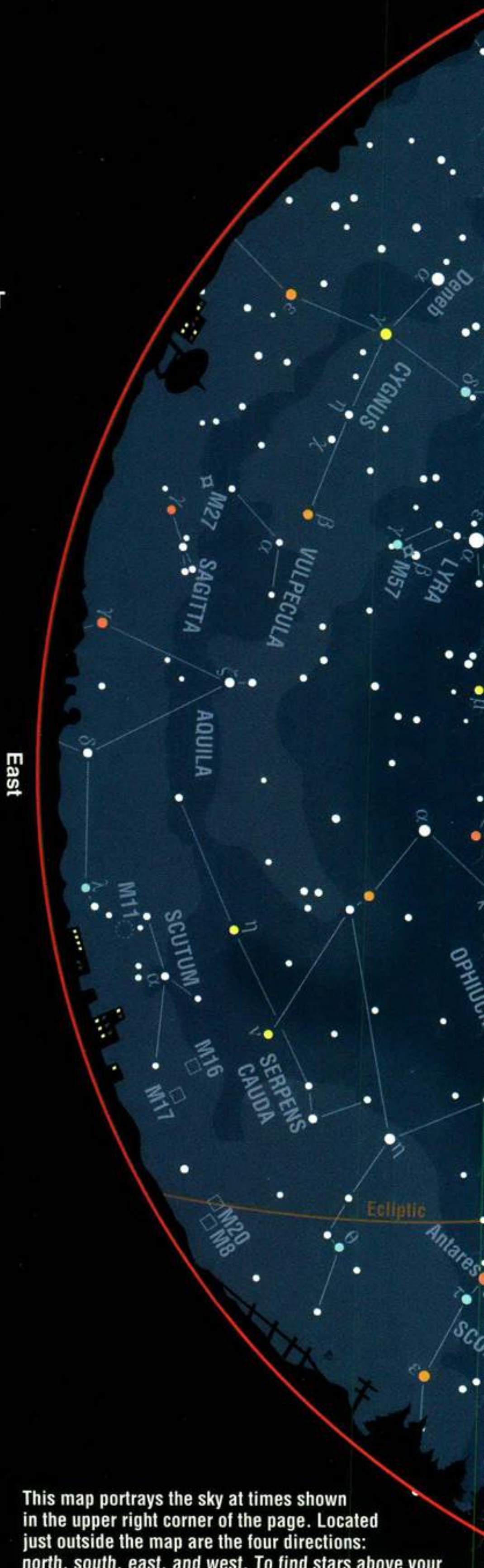
25 First Quarter Moon is at 10:13 a.m. EDT

29 Asteroid Ceres is at opposition (page 61)

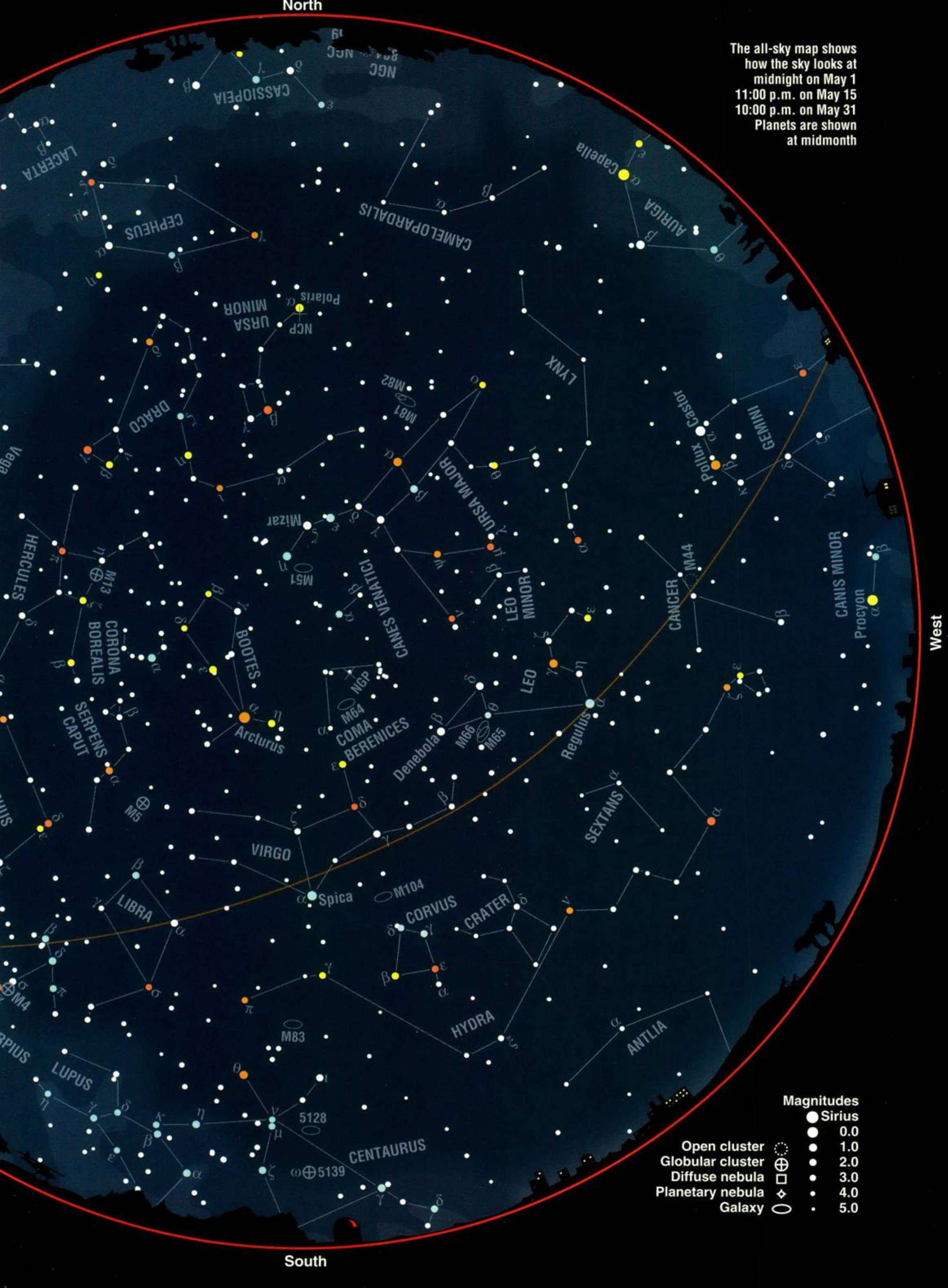
31 Mercury passes 4° south of Mars, 2 a.m. EDT



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

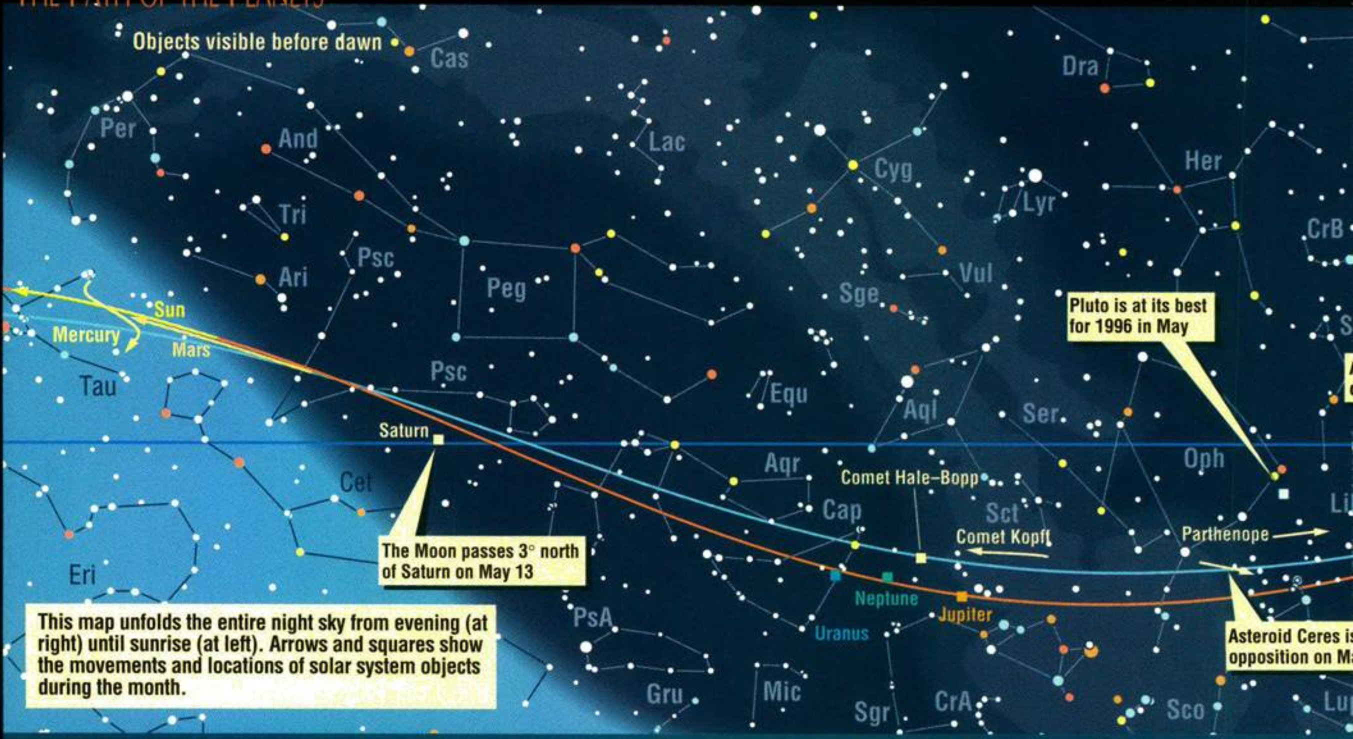


This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: *north, south, east, and west.* To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
South
West
CASSIOPEIA
NGC
LACERTA
CEPHEUS
CAMELOPARDALIS
Capella
AURIGA
URSA MINOR
Polaris
NCP
DRACO
Vega
M82
M81
LYNX
Castor
Pollux
GEMINI
URSA MAJOR
Mizar
M51
CANES VENATICI
HERCULES
M13
LEO MINOR
M44
CANCER
CANIS MINOR
Procyon
CORONA BOREALIS
BOOTES
NGP
LEO
M64
COMA BERENICES
SERPENS CAPUT
Arcturus
Denebola
M66
M65
Regulus
M5
SEXTANS
VIRGO
M104
Spica
LIBRA
CORVUS
CRATER
M4
HYDRA
M83
ANTLIA
LUPUS
5128
CENTAURUS
5139
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
midnight on May 1
11:00 p.m. on May 15
10:00 p.m. on May 31
Planets are shown
at midmonth

THE PATH OF THE PLANETS


Cas
Dra
Per
And
Lac
Cyg
Lyr
Her
Tri
CrB
Ari
Psc
Peg
Vul
Sge
Sun
Mercury
Mars
Tau
Psc
Equ
Aql
Ser
Saturn
Cet
Aqr
Oph
Comet Hale–Bopp
Cap
Sct
Comet Kopff
Parthenope
Eri
Neptune
Uranus
Jupiter
PsA
Gru
Mic
Sgr
CrA
Sco
Lup

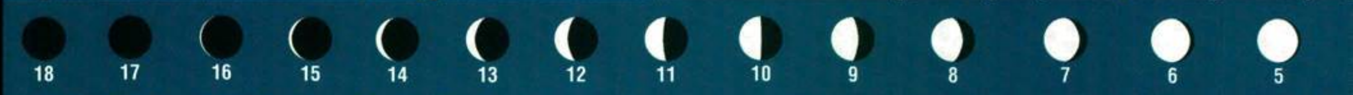
Objects visible before dawn

Pluto is at its best for 1996 in May

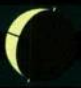
The Moon passes 3° north of Saturn on May 13

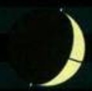
Asteroid Ceres is
opposition on Ma

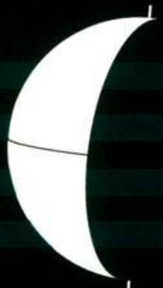
This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

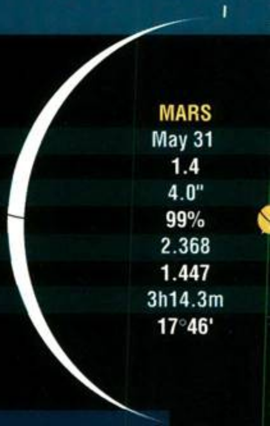

18
17
16
15
14
13
12
11
10
9
8
7
6
5

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.





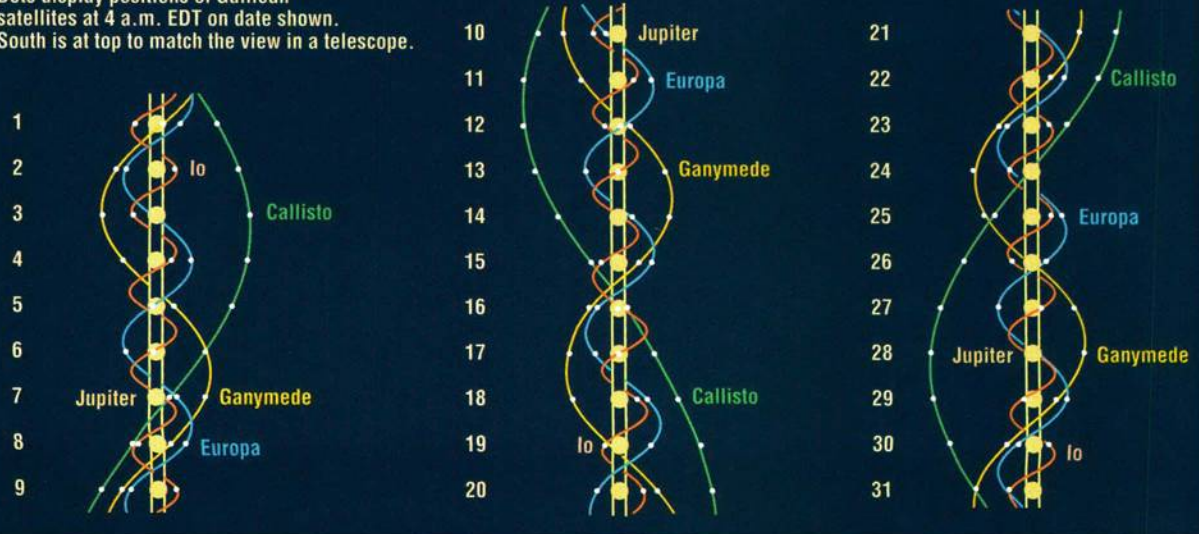


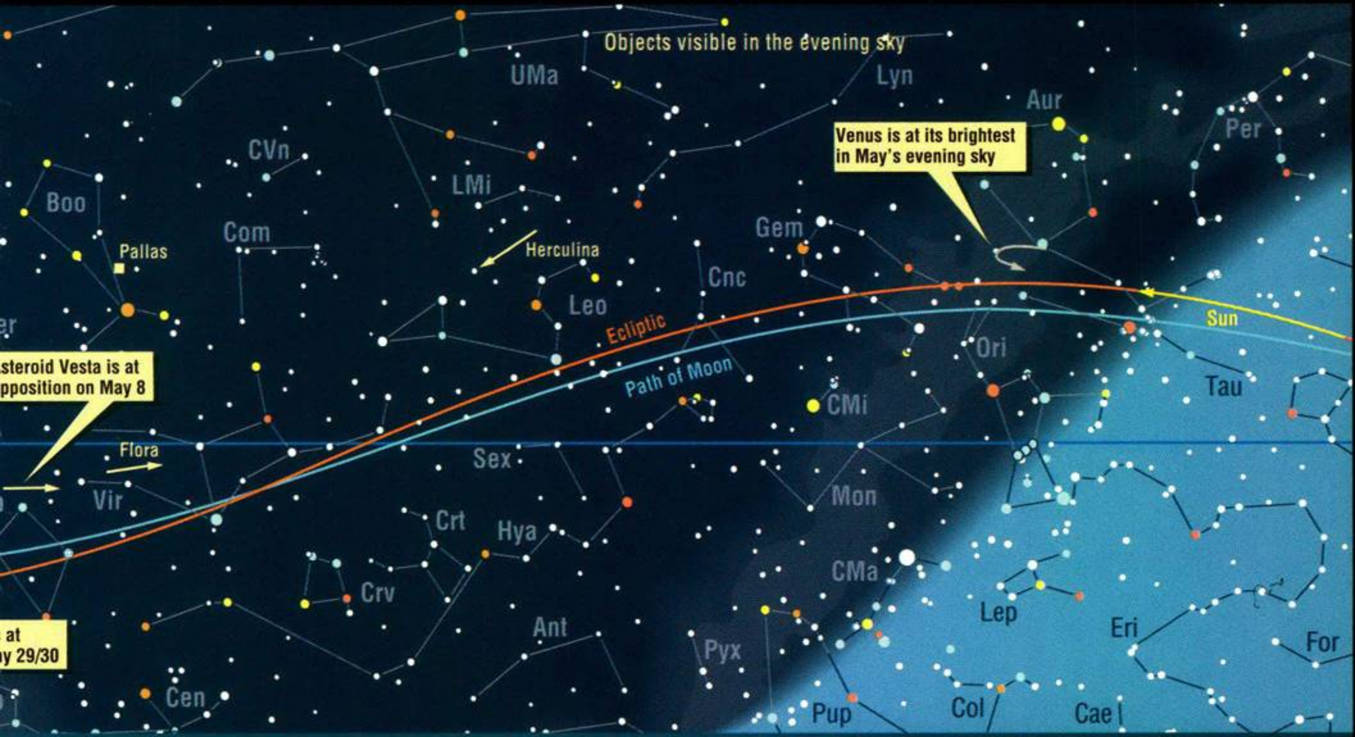


PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	May 1	May 31	May 1	May 31	May 31
Magnitude	1.6	1.7	–4.5	–4.2	1.4
Angular Size	9.6"	10.3"	34.8"	54.5"	4.0"
Illumination	17%	18%	31%	4%	99%
Distance (AU) from Earth	0.698	0.655	0.479	0.306	2.368
Distance (AU) from Sun	0.402	0.458	0.721	0.725	1.447
Right Ascension (2000.0)	3h41.8m	3h14.8m	5h24.5m	5h42.5m	3h14.3m
Declination (2000.0)	22°15'	14°07'	27°42'	25°16'	17°46'

JUPITER'S MOONS

Dots display positions of Galilean satellites at 4 a.m. EDT on date shown. South is at top to match the view in a telescope.

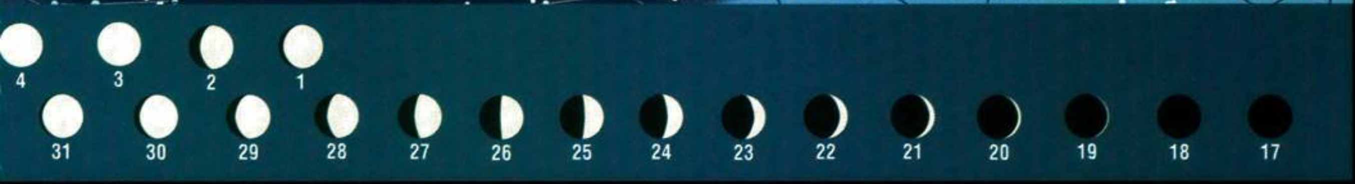


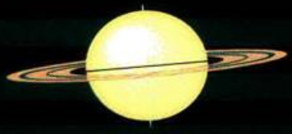

Objects visible in the evening sky
UMa
Lyn
Aur
Per
CVn
LMi
Boo
Pallas
Com
Herculina
Gem
Cnc
Leo
Ecliptic
Sun
Path of Moon
Ori
Tau
CMi
Flora
Sex
Vir
Mon
Crt
Hya
CMa
Crv
Lep
Eri
Ant
For
Pyx
Cen
Pup
Col
Cae
er

Venus is at its brightest in May's evening sky

steroid Vesta is at opposition on May 8

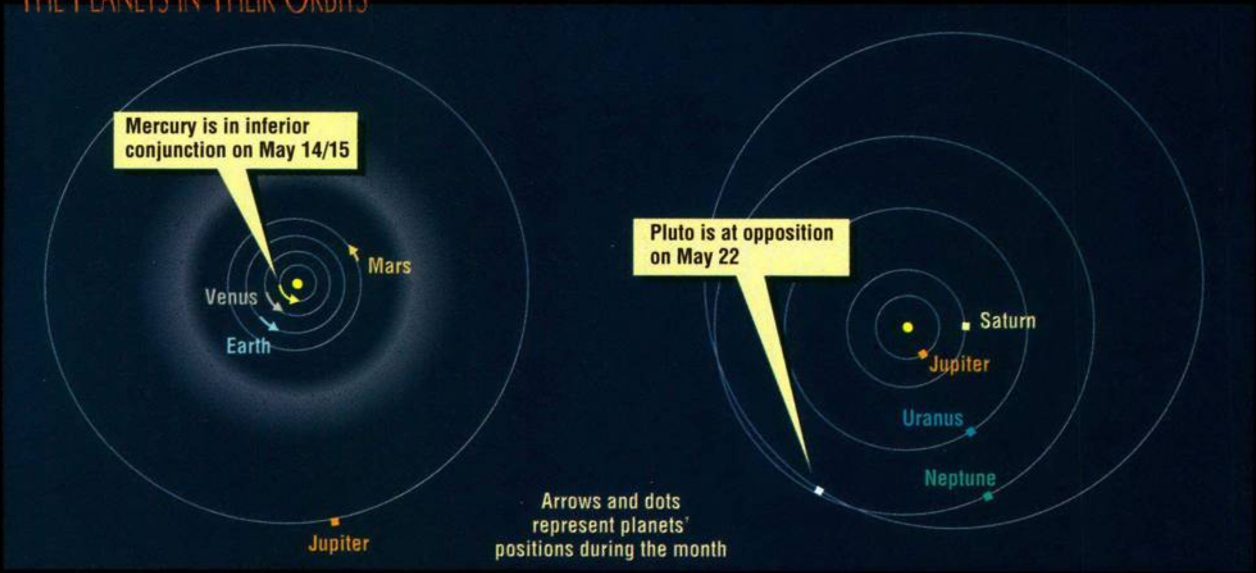
at
y 29/30


4
3
2
1
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17



JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
May 15	May 15	May 15	May 15	May 15
−2.5	1.0	5.7	7.9	13.7
43.3"	16.4"	3.6"	2.3"	0.1"
99%	100%	100%	100%	100%
4.551	10.151	19.399	29.693	28.926
5.221	9.538	19.766	30.162	29.902
19h16.0m	0h18.6m	20h28.4m	19h58.9m	16h10.3m
−22°15'	−0°18'	−19°41'	−20°08'	−7°21'

THE PLANETS IN THEIR ORBITS


Mars
Venus
Earth
Jupiter
Saturn
Jupiter
Uranus
Neptune

Mercury is in inferior conjunction on May 14/15

Pluto is at opposition on May 22

Arrows and dots represent planets' positions during the month inferior conjunction on May 14/15. Your best chance of sighting it comes very early in the month right after sunset. Find an unobstructed view toward the west-northwest and scan just above the horizon, below and to the right of Venus.

Mercury reappears in the morning sky at the end of the month, low in the east-northeast near **Mars**. Although both are difficult to see in the twilight, binoculars should bring them into view. Mars will be slightly better placed next month, and becomes an easy object by July.

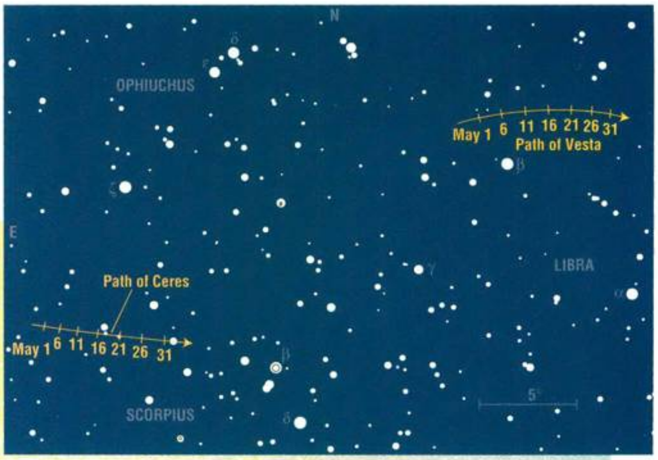
As evening twilight fades to darkness, the stars of spring reign supreme overhead. The Great Bear hovers over Leo Minor and its larger cousin, Leo. To the south and east, delicate Coma Berenices, faint Virgo, and Bootes the Herdsman form a stellar triumvirate, anchored by orange-red Arcturus, Bootes' brightest star.

Far to the south, two or three fist-widths above the horizon, we see the torqued little square of Corvus the Crow. To the west lies dim Crater the Cup on its side, its semicircle of faint stars open to the east. Below Corvus and Crater, stretching from east to west for over 90° of sky, lies the serpentine Hydra the Water Snake.

By midnight, the stars of summer begin rising. Leading the pack is Scorpius with smoldering Antares marking the heart of the Scorpion. Sagittarius, though not yet up, cannot be far behind.

Riding high in the east is Hercules. Look for its distinctive "keystone" asterism marking the torso of the son of Zeus. To the south looms the large, house-shaped Ophiuchus the Serpent Bearer, framed

First Views:
The Best Asteroids of 1996



This month the two brightest asteroids — 1 Ceres and 4 Vesta — grace our skies. Vesta can be glimpsed with the naked eye under good conditions and Ceres appears only slightly dimmer. A pair of binoculars offers an easy road to nabbing what could be the first pieces of your asteroid collection.

Ceres was the first asteroid discovered, by Giuseppe Piazzi on New Year's Day in 1801. Vesta came fourth (after Pallas and Juno), spotted by Heinrich Olbers on March 29, 1807. Ceres measures about 1,000 km across, twice the size of Vesta. Vesta appears brighter because it is more reflective and orbits closer to Earth. When favorably placed, as it is now, it ranks as the brightest of all asteroids.

Vesta reaches opposition on May 8, when it appears opposite the Sun in our sky and remains visible all night. It then lies closest to Earth and, this year at least, nearly at its closest to the Sun. These combine to make Vesta glow reasonably bright at magnitude 5.6, the only asteroid that ever reaches naked-eye visibility. At opposition it lies about 2.5° (half a binocular field) north of 3rd-magnitude Beta (β) Librae. If you wait until about midnight, Vesta will be due south, standing directly above this bright guide star. If you have dark skies, set the binoculars aside and see if you can spot Vesta with the eye alone.

Try making sketches of Vesta and its surrounding stars on consecutive nights and use them to reveal the asteroid's motion. Or if astrophotography suits you more, try to capture it on film. Load your camera with ISO 400 or faster film, set it on a tripod, and shoot the sky for 10 to 20 seconds with a 50mm lens open wide. Photos taken a night or two apart will show Vesta as a moving "star."

Meanwhile, Ceres slides silently north of sparkling Antares. On the evening of May 17, it scoots half the Moon's diameter south of a 5th-magnitude star, making the 7th-magnitude asteroid easy to identify. On the 18th, don't mistake Ceres for a 7th-magnitude star lying a mere 2' away. It makes a similar close pass by a slightly fainter star on the 21st. And it practically runs across 4th-magnitude Chi (χ) Ophiuchi on June 2, just after it reaches opposition on May 29/30. — *A. L.*

COORDINATES FOR CERES*

Date	R.A. (2000)	Dec.
May 1	16h54.3m	–17°43'
May 6	16h51.0m	–17°50'
May 11	16h47.3m	–17°57'
May 16	16h43.0m	–18°04'
May 21	16h38.5m	–18°11'
May 26	16h33.7m	–18°18'
May 31	16h28.9m	–18°26'

*Positions given for 11 p.m. EDT

COORDINATES FOR VESTA*

Date	R.A. (2000)	Dec.
May 1	15h22.9m	–7°01'
May 6	15h18.2m	–6°50'
May 11	15h13.3m	–6°42'
May 16	15h08.4m	–6°38'
May 21	15h03.7m	–6°38'
May 26	14h59.4m	–6°42'
May 31	14h55.6m	–6°51'

*Positions given for 11 p.m. EDT

by Serpens Caput to the west and Serpens Cauda to the east.

Rising close to midnight (and growing brighter by the month), we see **Jupiter** gracing the star-rich clouds of the eastern Milky Way in Sagittarius. At magnitude –2.5, it ranks as the fourth-brightest object in the sky, after the Sun, Moon, and Venus.

Ten degrees north and east of Jupiter lies magnitude 7.9 **Neptune**. You'll need a telescope and fairly high magnification to discern it as a blue-gray dot among the stars. Although magnitude 5.7 **Uranus** can be glimpsed with binoculars, you'll need a scope to see its small, blue-green disk. Look about 5° southeast of Beta (β) Capricorni.

Turning our attention west along the Scorpius-Ophiuchus border, and more specifically 3.5° southwest of Delta (δ) and Epsilon (ε) Ophiuchi, we enter the current realm of **Pluto**. This month marks the best time this year to look for Pluto because the planet reaches opposition on May 22. The planet rises at sunset and remains in the sky all night.

To see it, you'll need at least an 8-inch telescope, a little determination, and an accurate finder chart (like the one provided in the article "Observing to the Edge," page 70). At magnitude 13.7, however, this planet won't leap out at you, nor take your breath away once you locate it. But you can take satisfaction at finding it floating among the stars, especially if you've never succeeded at such a feat before.

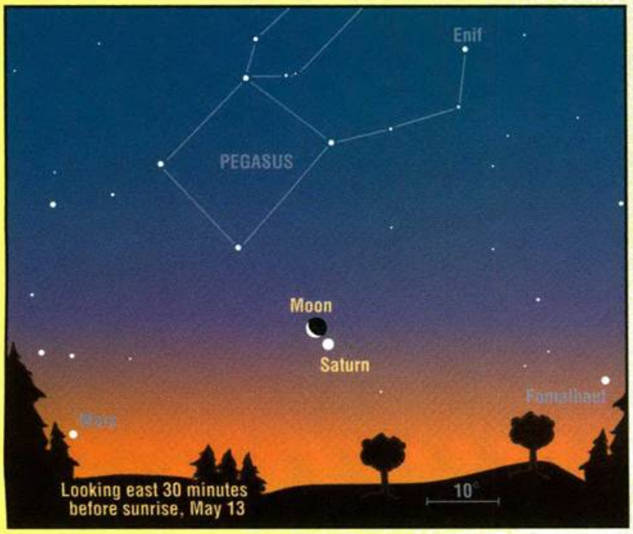
After Pluto crosses the meridian around midnight, you can find Draco the Dragon in the north, entwined around the Little Dipper. The head of the Dragon nips at the feet of Hercules. East of the Draco-Hercules line lie the three bright stars of summer: Brilliant Vega in Lyra is westernmost; Deneb of Cygnus the northernmost; and Altair of Aquila marks the southern corner. Both Deneb and Altair lie embedded in the summer Milky Way, which, if your sky is dark and clear, should be apparent as a ghostly mist rising from the southeastern horizon toward the north.

The hours leading up to dawn unfold the autumn sky — diminutive Delphinus, Pegasus and its distinctive Great Square, Andromeda at the eastern extreme, and Pisces low in the east. The circumpolar groups coming into view

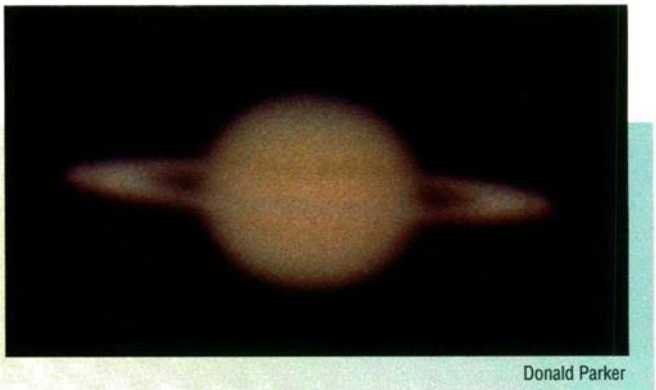
Return of the Ringed Planet

After being hidden near the Sun's glare, Saturn slowly emerges into the dawn twilight this month. The edge-on ring events of the most recent apparition have ended and the magnificent ring system will gradually open up over the next six years.

The rings are tilted about 5° to us, presenting their southern face. Under good seeing conditions, a 6-inch or larger scope should show Cassini's division, but only toward the ansae, or outer part of the rings. Also watch for the shadow of the planet on the rings — it's a breathtaking 3-dimensional effect you won't see at opposition in September, when the Sun, Earth, and Saturn line up and the shadow hides behind the disk.



Looking east 30 minutes before sunrise, May 13



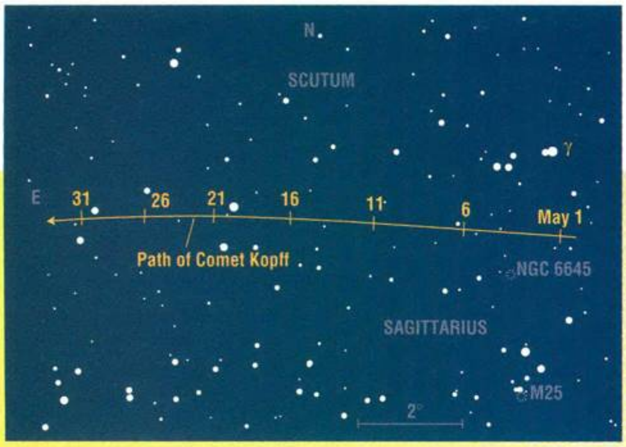
Donald Parker

Because the rings are not fully open and bright, this summer is a good time to watch for the fainter satellites that circle not far from the rings. Inside the orbits of the brighter Titan and Rhea, the moons Dione and Tethys glow at 10th magnitude and are relatively easy to follow in smaller instruments. Enceladus and Mimas are a drop down in magnitude, shining feebly at 12th and 13th magnitude near the glare of the rings. You'll want at least an 8-inch scope to nab these smaller moons.

Saturn is not all rings and moons however. Its clouds offer an arrangement of pastel yellow-brown bands. The shadow of the rings on the cloudtops will show up as a thin dark line where the rings appear to join the globe. Saturn also has the most flattened appearance of all the gas giant planets, 10 percent, compared with Jupiter's 6 percent flattening.

By the end of May, Saturn stands alone 30° above the east-southeastern horizon when dawn arrives. Just like last summer, Saturn glides slowly against a region of the sky devoid of bright stars. The ringed wonder appears as a non-twinkling, yellowish, 1st-magnitude "star" southeast of the Pisces circlet, which lies below the Great Square of Pegasus. The brightest nearby stars shine at only 4th and 5th magnitude. — *A. L.*

A Tale of Two Bright Comets



COORDINATES FOR COMET KOPFF*

Date	R.A. (2000)	Dec.
May 1	18h28.6m	–16°12'
May 6	18h36.3m	–16°03'
May 11	18h43.5m	–15°56'
May 16	18h50.2m	–15°50'
May 21	18h56.4m	–15°46'
May 26	19h01.9m	–15°46'
May 31	19h06.7m	–15°50'

*Positions given for 4 a.m. EDT

We may remember 1996 as the year of the comet. Not only do we have the continuing story of Hale-Bopp (see below), but this month offers two other bright comets worth taking a look at.

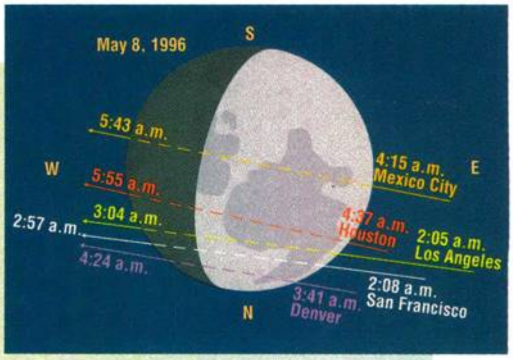
First up is periodic Comet Kopff, which this month can be seen crossing the starry river of the Milky Way. This interplanetary snowball has a modestly short period of 6.5 years and resides in the inner solar system, living the orbital life of an asteroid — from just outside Jupiter to just outside Mars.

This year Kopff tacks on a right angle course across the summer Milky Way, coming up around midnight during May. On the first four nights of May, you can find the comet cruising less than 1° north of the faint but rich star cluster NGC 6645 in Sagittarius, but the nearly Full Moon interferes considerably with the view. For the rest of the month, Kopff sails the deep-sky doldrums along the southern edge of Scutum. There are lots of stars, but no sign of clusters or nebulae.

Small telescopes at low power will give a delightful view of Kopff in front of a rich Milky Way starfield. The comet's 8th-magnitude glow should display a fan-shaped figure a few arcminutes across, brightening to a core. You will need medium power — over 120x — to spot differences between the sharper leading edge and the more diffuse tail. You can expect Kopff to brighten to 7th magnitude around the time it peaks in early July.

Comet Hyakutake (1996b_2), on the other hand, may reach magnitude 0 this month. Discovered in late January, this newcomer passed close to Earth in late March and now lies close to the Sun, making it very difficult to see. For more on Hyakutake, see the story beginning on page 82. — *A. L.*

The Moon Covers Hale-Bopp



Just the mention of Comet Hale-Bopp excites observers with thoughts of what's to come. Will it be the comet of the decade, or the generation, when it graces the sky next spring? All eyes are focusing on it now to see if it continues brightening, a sign that it should match predictions this coming year.

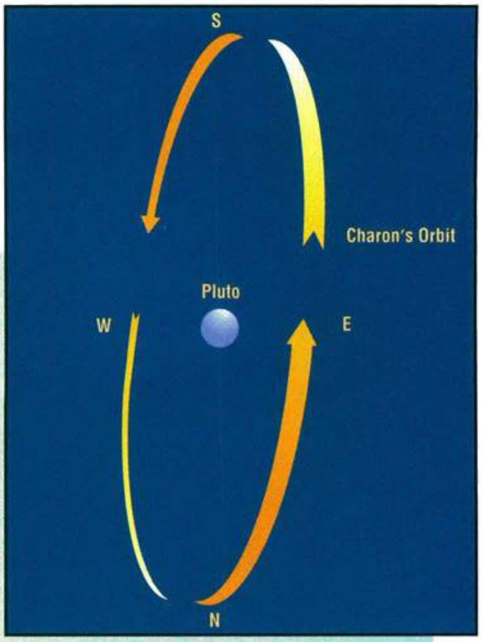
But there's another reason to keep your eye on Hale-Bopp this month. Observers from about Denver westward and south of the Canadian border have a rare chance to see the comet emerge from behind the dark limb of the Moon, about an hour before sunrise on May 8. Those east of Kansas City are out of luck because the Sun rises before the Moon uncovers Hale-Bopp.

The diagram gives you a general idea of when the comet reappears for your area, as well as where along the Moon's limb it emerges. Here are some hints to increase your chances of seeing this unusual event: Keep the lit part of the Moon out of the way, leaving only the small area of its dark limb in the field of view. Use a scope with a clock drive, so the Moon doesn't constantly float into the field and dazzle your eye. Try medium power, say 100x to 200x, to keep as much contrast as possible. Because the Moon brightens the nearby sky, you may see the 7th- or 8th-magnitude comet as only a small fuzzy spot after it reappears.

Except for this occultation, Hale-Bopp appears best when the Moon is out of the early morning sky, toward the end of the month. It currently lies slightly east of the "teaspoon" asterism, to the left of Sagittarius' famous teapot arrangement of bright stars. Be sure to look for it on the mornings of the 12th and 13th, when the comet ambles just south of the 5.3-magnitude star 54 Sagittarii. — *A. L.*

Observer's Challenge:

Can You Spot Pluto's Moon?



Okay big scope owners — you say Pluto's too easy for you? Then try for its diminutive moon, Charon. Charon was discovered in 1978 by James Christy, who noticed a bulge on Pluto's photographic image. Duplicating this feat visually ranks as one of the most daunting challenges in amateur astronomy, but it is possible.

Charon's orbit lies nearly edge-on to our line of sight to Pluto, making the pair tough to split unless the moon lies near greatest elongation. The table gives the dates and times this month when Charon reaches greatest northern and southern elongation. Even then, however, Charon ranges only 1" from Pluto, a fair bit tighter than the famous Double Double in Lyra, whose component stars lie about 2.5" apart.

You'll need a 24-inch or larger scope to ferret out 17th-magnitude Charon. If you're fortunate enough to have a truly dark site and can see stars as faint as this with a 20-incher, then go for it! To achieve this Olympian feat, everything has to be just right, including having a good elongation from Pluto. The sky should be as dark as possible but, more important, it has to be steady. Avoid looking over buildings or parking lots, which absorb heat during the day and release it at night. And make sure the scope and mirror have had time to cool down to the ambient air temperature to avoid tube currents.

Use the highest magnification the sky allows — slip in a Barlow lens if you have one — and crank up the power past 600x. Allow your eyes to adapt to the darkness of the field, and be patient. Watch for several minutes because variable seeing may cause Charon to pop in and out of sight.

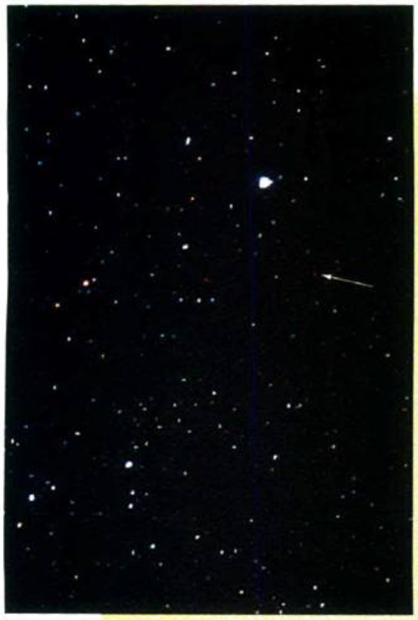
Submit your observations to ASTRONOMY. It will make quite a story if you succeed. — *A. L.*

ELONGATIONS OF CHARON

Date	Time
May 2	**3:12 p.m.**
May 5	7:48 p.m.
May 9	**12:30 a.m.**
May 12	5:06 a.m.
May 15	**9:48 a.m.**
May 18	2:30 p.m.
May 21	**7:12 p.m.**
May 25	11:48 p.m.
May 28	**4:30 a.m.**
May 31	9:06 a.m.

Northern elongations are in boldface and southern elongations in normal type. Times are given in eastern daylight time.

A Red Star for Spring Nights



Stephen Walther

Stars span a spectrum of colors. It's easy to find the brilliant bluish-white Vega and the orange Betelgeuse and Antares. If you want traffic-light red, you have to dip into the world of the variables, and there you'll find ruby treasures like T Lyrae.

You'll need a careful starhop to get to T Lyrae — use the photo to be sure where you're going. T is an irregular variable star, and as it changes from 8th to 10th magnitude so does its color, deepening from orange-red to deep red.

Even from the city, this red variable is visible with a 4-inch scope. A smaller scope simply won't collect enough light to make the color receptors in your eyes respond. A neat thing about colored stars is that you have to look directly at them. The averted vision we use to enhance deep-sky objects is black and white. When you stare at this red star, you may notice that it gets a bit brighter as your eye becomes more sensitive to the color.

As you bask in the warm glow of T Lyrae's red light, you're seeing the embers of a celestial campfire. Carbon stars like T Lyrae eject carbon compounds into their extended stellar atmospheres. The carbon glows at different temperatures depending on its distance from the star, producing a range of reddish colors like the coals of a campfire. — *A. L.*

then are first Cepheus, then the zigzag shape of Cassiopeia. When you see Perseus climbing into the sky, you know that sunrise won't be too far behind.

Lingering night owls and early risers can glimpse **Saturn** in the east an hour or so before dawn. It lies in southern Pisces, situated between the familiar shape of Pisces to the north and east, Cetus to the east, and Aquarius to the south and west.

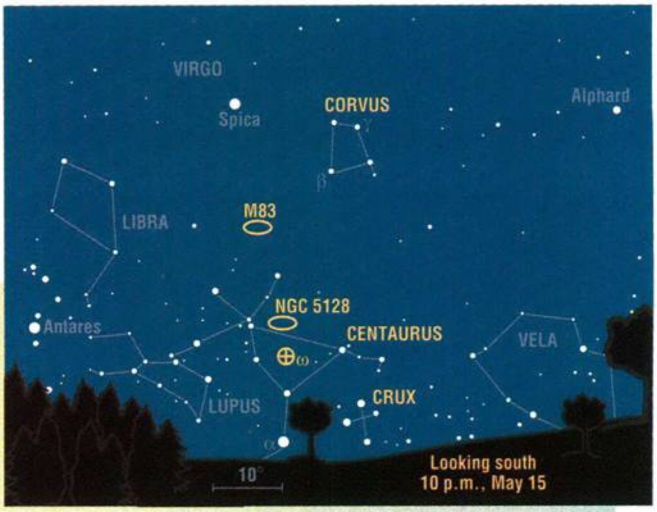
Since February, when Earth passed through the ring-plane for the final time, Saturn has been more inclined to show us her rings. The rings tilt 5° now, with the south face visible.

On May 13, Saturn lies a little less than 2.5° below the lower horn of the waning crescent Moon. A beautiful sight, no doubt, for those with an eye for Moon-planet aesthetics.

Finally, be sure to catch what you can of the Eta Aquarid meteor shower on the morning of May 5. Unfortunately, conditions for this year's display are not optimal, for two reasons. First, the Full Moon interferes with the fainter members of this stream. And second, for North American observers, the shower's peak comes during the afternoon hours of the 4th. Nevertheless, the Eta Aquarids should be strong enough on the mornings of the 4th and 5th to produce a few fast, bright meteors, and perhaps even a yellow fireball or two. Start looking around 2 a.m. local time when the shower's radiant — located in the "water jar" of Aquarius — rises in the east. ☐

Jeff Kanipe is ASTRONOMY*'s managing editor. Alister Ling is a meteorologist with Environment Canada.*

The Starry Sky:
Corvus and the Way South



Looking south
10 p.m., May 15

Corvus the Crow's appearance on the meridian each May evokes two reactions from me. First, it is a sign that the summer sky is on the way back, and that spring is all but gone. I can begin looking forward to the glorious pageantry of Scorpius and Sagittarius, and the breathtaking Milky Way star clouds.

But the constellation's southerly location serves as a reminder to those of us in the Northern Hemisphere that the sky doesn't stop at the horizon. If only we could roll Earth out of the way.

Because it looks sort of rectangular, Corvus appears to me as a doorway south. From its threshold the south celestial pole lies a full 65° away — a lot of sky. Although most of this sky is beyond the reach of observers in the Northern Hemisphere, good timing and the right location can provide you with the opportunity to catch a tantalizing glimpse of a few southern sky treasures.

Corvus makes a good pointer to Crux, the Southern Cross, which lies a mere 35° due south and crosses the meridian around 9:50 p.m. local time in mid-May. If you want to see the constellation hovering well above the horizon from the Northern Hemisphere, you might head for Hawaii. There are, however, two privileged locations in the continental United States that, when sky and horizon conditions are favorable, provide a view of the upper part, if not all, of Crux. These are the Florida Keys and extreme south Texas. Above latitude 30°, though, you're out of luck. The northernmost star in Crux, Gamma Crucis, just doesn't reach a favorable enough altitude. In New Orleans, for example, Gamma reaches only 3° above the southern horizon at best.

Other southern sky wonders can be glimpsed from farther north, however. A latitude of 30° to 33° north provides an adequate view of Omega Centauri, the best of all the globular clusters. Over half-a-million stars strong, this object looks to the naked eye like a cotton ball set amid the spangly stars of Centaurus. I have seen it many times shining clearly through oak and cedar scrub on the Llano River in central Texas, at a latitude of 30° north. Even from a latitude of 33°, Omega peaks at 10°, which is within reach of eye or telescope.

And there's more. If you can see Omega Centauri, you should have no trouble seeing NGC 5128, known as Centaurus A, located just 4° due north. NGC 5128 is that weird-looking galaxy with the identity complex. It appears to be an elliptical type because of its overall spherical shape, but it also has this wide belt of dark dust girdling it.

To see it well, though, you'll need a telescope and moderate magnification. A 6-inch is large enough to show a globe of glaucous light bisected neatly by that distinctive wide band of dust. And in telescopes of 16 inches or larger, its strange nature becomes obvious.

At –30° declination, you'll come across M83, a fine spiral with a bright nucleus and compelling scythe-like arms. This object can be seen from most locations in the United States (it reaches a maximum altitude of 18° in Boston, for example), but surprisingly few observers have seen it because they tend to concentrate on what's overhead, not what's hanging out near the horizon. Use Gamma (γ) and Beta (β) Corvi as pointers. Follow the line they indicate 15° southeast and scan with your Dob or SCT. You can't miss it.

Like the song says, you can't always get what you want. For those of us longing for a taste of southern skies from the Northern Hemisphere, this is sadly true. But with persistence and some strategic horizon hopping, we may be able to get what we need for now via Corvus' southern passage. — *Jeff Kanipe*

The Star Partier's

Tank up the car . . . pack all the equipment . . . round up the family. There's a universe of star parties awaiting you this summer from coast to star-splashed coast.

by John Shibley

It's the summer travel season once again. What'll it be this year? Yellowstone? That same old summer cottage? Maybe it's time for a change of scene.

How about a summer star party? Think of any tourist destination in the U.S. and Canada and there's likely a star party close by it this summer. Why not combine the family vacation with astronomy? While the family enjoys the sights and sounds of summer, you could be getting your fill of sky, scopes, cameras, and the cosmos.

And there's probably a star party near or even within your state or province. In days gone by, amateur astronomy was synonymous with the solitary observer. Today people flock to star parties in record numbers that are usually no more than a day's drive away from home. These gatherings hold future friends and, of course, celestial vistas just waiting to be seen.

To get a handle on what summer star parties offer, ASTRONOMY has put together this short list that runs from June through the height of summer.

Each party has a date, a brief description of what it offers, and where to get more info.

But the star party scene is in a constant state of evolution. Consult ASTRONOMY's monthly "Meeting and Events" column for new parties appearing on the horizon.

June 1996

June 6-7 (Sedona, Arizona). Astrophotography and telescope workshops by day; guided tours of the sky by night. This best describes the 11th-annual **Astronomy Festival of Red Rock**, presented jointly by the Sedona and Cottonwood Astronomical Societies. The Red Rock State Park site is home to a 4-inch solar telescope modeled after the famous solar facility on Kitt Peak. This year two professional astronomers give evening lectures. Write Russell A. Nedey, 1101 Zalesky Road, Cottonwood, AZ 86326, or call (520) 634-7332.

June 8-16 (Grand Canyon, Arizona). The San Francisco Sidewalk Astronomers (SFSA) and the National Park Service team up to offer the **Grand Canyon Star Party** on the famed canyon's 7,000-foot North Rim. Over 200 amateur astronomers show off telescopes and images of the Sun to park visitors during the day. Activities carry over into early evening public observing sessions, followed by independent observing and astrophotography all night. This year the SFSA makes a telescope from scratch (including the mirror) for a local school. Contact Dean Ketelsen, 1122 East Greenlee Place, Tucson, AZ 85719, (520) 293-2855, e-mail: ketelsen@as.arizona.edu.

June 14-15 (Dayton, Ohio). Telescope making, astrophotography, astronomy lectures: It's all part of **Apollo Rendezvous '96** at Dayton's Museum of Natural History. Co-organized with the Miami Valley Astronomical Society, the event uses the museum's 171-seat planetarium and observatory equipped with a 20-inch telescope. The featured talk is a virtual tour of the solar system using Hubble Space Telescope pictures. Other activities include a flea market, a mirror-grinding demonstration, an astrophotography contest, and presentation of the latest in amateur-built adaptive optics. Contact John A. Schroer, 2600 Deweese Parkway, Dayton, OH 45414, (513) 275-7431, ext. 36, e-mail: JschroerIV@usa.pipeline.com.

Hear the latest tips

Guide to Summer

Land a bargain

June 14-16 (Shrewsbury, Pennsylvania). The York County Parks Astronomical Society presents the **Mason-Dixon Star Party** at Spring Valley County Park, just seven miles north of the Pennsylvania/Maryland border and 15 miles south of York. Last year over 200 people camped and observed on a large, grassy field. Events include Solar observation with an Hα filter and an astrophotography and homemade telescope contest. For more information, write Jeri Jones, 400 Mundis Race Road, York, PA 17402, or call Todd Ullery at (717) 235-1153, e-mail him at Ullery@act.org.

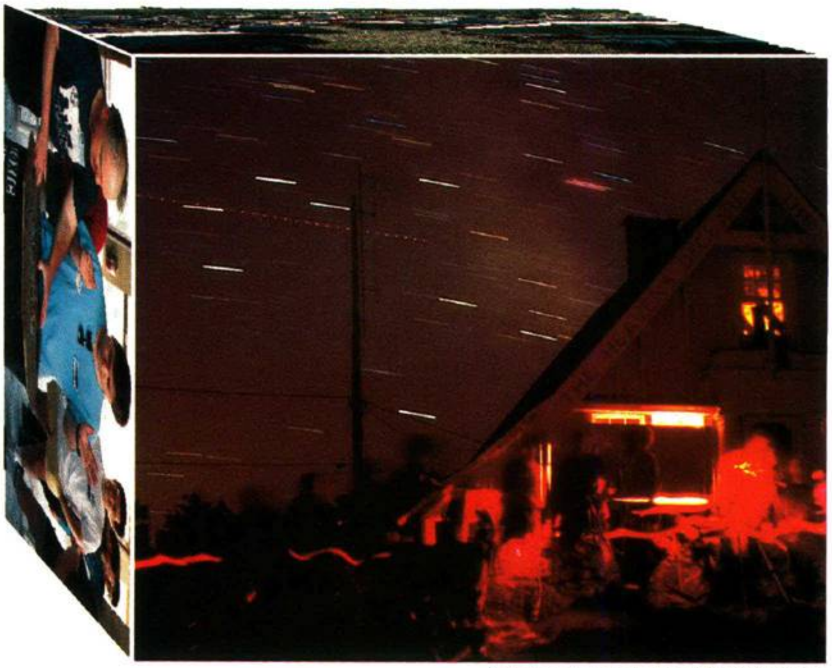
June 14-16 (Sussex, New Jersey). The Amateur Astronomers Association of Princeton hold **Jersey Star Quest VI** at the Beemerville 4-H Camp near High Point State Park. Star Quest features a Messier-hunting contest, lectures, a swap meet, commercial vendors, door prizes, and an astrophotography workshop. Contact Greg Mauro, 4 Crosswicks Court, Trenton, NJ 08610, (609) 585-9465 (from 7-9 p.m.). Registration deadline is May 30th.

June 14-16 (Waupaca, Wisconsin). Wisconsin Observers' Weekend (WOW) 1996 meets at Hartman Creek State Park for a weekend of observing under the state's darkest skies. No daytime talks mean extra sleep or some time to enjoy canoeing, swimming, hiking, and fishing. Get more details from Don Wyman, 1065 Laager Lane, Oshkosh, WI 54901; e-mail: dwyman@athenet.net.

June 14-16 (Johnson City, Texas). The **Central Texas Star Party** is hosted by the Austin Astronomical Society (AAS) at Pedernales Falls State Park, some 40 miles west of Texas' capitol city Austin. This year the Society builds a split-roof observatory to house a 16-inch reflector. While in the area, visit President Lyndon Johnson's ranch outside of nearby Johnson City. For more information about the star party, contact Kelly Knight, AAS, P.O. Box 12831, Austin, TX 78711-2831, (512) 447-1163.

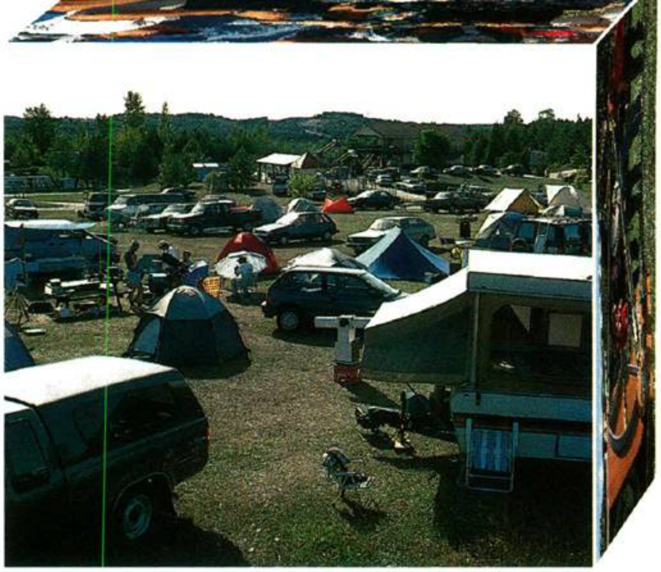
June 21-23 (Vernonia, Oregon). Amateur astronomy commingles with ham radio during the Northwest Astronomy Net's Fieldstar '96 at the club's Vernonia Peak Observatory. The building houses a 12 ½-inch Newtonian-Cassegrain telescope as well as a 24-inch scope with adaptive optics that might be up and running in time for the party. Daytime activities are a tailgate swap-meet, impromptu telescope judging, displays by commercial vendors, and talks given by professional astronomers. Contact Sandy Mikalow, 55371 McDonald Road, Vernonia, OR 97064, (503) 429-2430, e-mail: inchcape@teleport.com.

June 21-23 (Alma, New Brunswick). Canada's Fundy National Park, located 35 miles up the coast from Saint John, forms a backdrop to **Astro-Atlantic '96**, hosted by the New Brunswick Astron-



Soak up summer's Milky Way

Kevin Jones / all other photos ASTRONOMY staff



Camp under the stars.

omy Club. The park offers a dark site at 1,000 feet, plus full camping facilities, including showers and kitchens. Daytime talks will be given by Canadian amateur and professional astronomers. Explore the seashore and witness the Bay of Fundy's radical tides. Contact Doug St. Onge, 4 Campbell Sreet, Gondola Point, New Brunswick E2E-1N7 Canada, (506) 847-1923, e-mail (case sensitive: Doug.StOnge@p2.f19.n255.z1.fidonet.org.

June 22-23 (Santa Clara, California). ASTRONOMY magazine, the Astronomical Society of the Pacific, and NASA's Ames Research Center bring you **Universe '96** at the Westin Hotel in Santa Clara. Professional astronomers on the cutting edge of their fields give two-day talks while dozens of commercial vendors gather to show off the latest in equipment and services. ASTRONOMY's staff and noted amateur astronomers explore what the hobby of astronomy offers. Contact Universe '96, 390 Ashton Avenue, San Francisco, CA 94112; (415)337-1100, fax: (415) 337-5205, e-mail: asp@bkyast.berkeley.edu.

July 1996

July 12-14 (Austin, Minnesota). Midwesterners beat a path to the Cedar River Astronomy Club's **Star Party** three miles outside of Austin. Maybe it's the club observatory built by the city of Austin that's attracting attention. Or perhaps the 12-plus large-aperture telescopes that show up year after year. You decide. For more information write Keith Snyder, 407 15th Sreet, SE Austin MN 55912, or e-mail kdsnyder@wolf.co.net. CRAC's Web site is http://wavefront.com/~alaaby/imstar/imstar.html.

July 12-14 (Lake George, Colorado). The Colorado Springs Astronomical Society, organizers of the 10th annual **Rocky Mountain Star Stare**, claim that observers at their party often confuse the Milky Way for clouds. Is it transparent skies at 8,700 feet or hypoxia? Judge for yourself. But save some energy for interesting daytime astronomy talks. Contact Michael M. Frazier, 4980 Bluestream Drive, Colorado Springs, CO 80917, (719) 591-9349, e-mail: mfrazier@us.oracle.com. Don't forget to check out the CSAS Web site at http://www.UCCS.edu/~cwetheri/Astro/CSAS/.

July 12-14 (Powassan, Ontario). Northern Ontario's north woods and dark night skies are the venue for **Gateway to the Universe**, hosted by the North Bay Astronomical Society. The club leases a private campground for the two-day deep-sky observing-fest. Time is also set aside during the day for talks and a swap meet. Contact Tom Ouellette, 221 Mulligan Sreet, North Bay, Ontario P1A 3P4 Canada, phone (705) 474-7666.

July 25-27 (Rockford, Illinois). The Rockford Amateur Astronomers (RAA) welcome the Astronomical League's annual convention **Astrocon '96** to Rockford College. This will be a joint meeting with the Association of Lunar and Planetary Observers, an organization whose members specialize in doing scientific observation of solar system objects. Convention highlights include observing sessions, a special barbecue, speakers from professional astronomy, a solar observing workshop, and tours of Yerkes and Lockwood Park Observatories. Write to the RAA, 6804 Alvina Road, Rockford, IL 61101-7952, e-mail: praesepe44@aol.com.

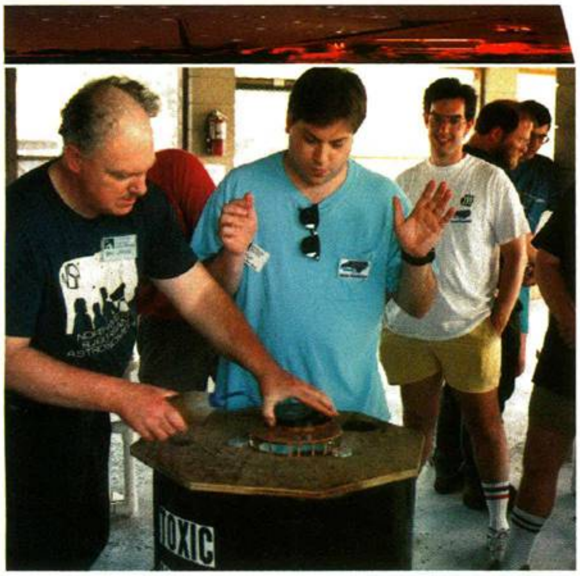
August 1996

August 8-10 (Foxpark, Wyoming). The is the sixth summer for **Weekend Under the Stars**, a star party hosted by the Cheyenne Astronomical Society under west Wyoming skies. Organizers say the limiting naked-eye magnitude reaches 7 at the 9,100-foot site. On Saturday tour the University of Wyoming's 92-inch infrared telescope. Speakers and the awarding of door prizes follow later that evening. Get an information packet by calling (307) 635-5944, or e-mailing lcmcuran@antelope.wcc.edu. Be sure to leave your name and address.

August 8-12 (Mt. Forest, Ontario). The North York Astronomical Association sponsors **Starfest**, held on a 200-acre campground 75 miles northwest of Toronto. This year Starfest features all-night stargazing and a Perseid meteor watch. Contact Andreas Gada, 26 Chryessa Avenue., Toronto, Ontario M6N 4T5 Canada, (416) 761-1798. Also, e-mail Tony Ward at tward@databridge.com.

August 8-10 (Virginia City, Montana). "Observe 'til you drop" are buzz words for this year's **Montana Starwatch**, put on by the Southwest Montana Astronomical Society. Besides taking advantage of some the darkest skies east of the continental divide, MSP has daytime talks by professional astronomers as well as several mountain wilderness excursions. Contact Donna Sweeney at 2410 Avalon Rd., Billings, MT 59102, or e-mail Mike Murray at ammmm@gemini.oscs.montana.edu.

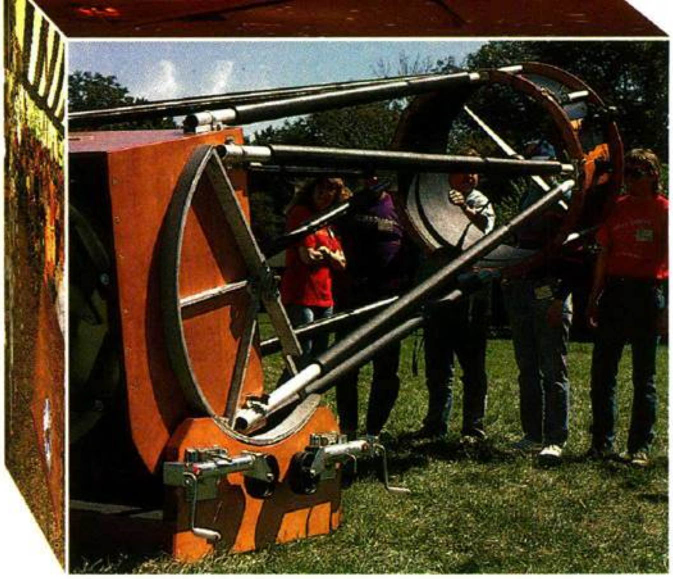
August 9-10 (Springfield, Vermont). Stellafane, hosted by the Springfield Telescope Makers, has attracted amateur telescope makers from all over the world since its inception in the 1930s. ATM enthusiasts freely intermingle with people looking to do some simple deep-sky observing. Stellafane also has the mother of all swap meets, where you can find many forms of used equipment and rare books. Don't forget to check out the unique Porter Turret Telescope. For more information, write Stellafane, P.O. Box 50, Belmont, MA 02178.



Make a telescope.

August 10-17 (Valentine, Nebraska). The Prairie Astronomy Club's third annual **Nebraska Star Party** has the Perseid meteor shower as its center piece this year. But the main impetus for NSP is deep-sky observing. Organizers have made this a contest by drawing up lists of easy, intermediate, and hard targets to find in a variety of instruments. Campers get awards for how much of each list they observe. Contact Tom Miller, 3400 N. 102nd Sreet, Lincoln, NE 68527, (402) 466-4170.

August 14-18 (Mt. Kobau, British Columbia). For more than 10 years Canadian amateur astronomers have been flocking to a 6,000-foot mountain to hold **Kobau Star Party** under the stars. KSP focuses on deep-sky observing, pure and simple: no talks, workshops, or organized daytime activities to wake up for. Last year 175 observers were treated to five straight nights of clear skies. Contact Peter Kuzel, 4100 25th Avenue, Vernon, British Columbia V1T 1P4 Canada.



Ogle monster scopes.

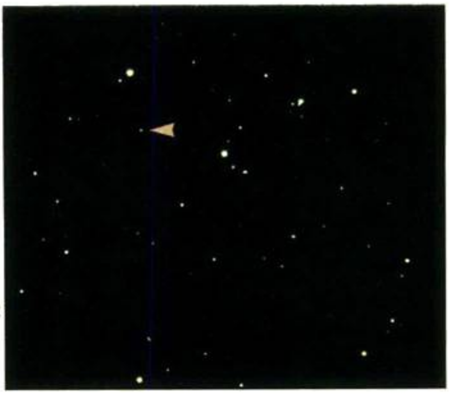
August 15-18 (Prineville, Oregon). The **Oregon Star Party**, cosponsored by the Rose City Astronomers and the Oregon Museum of Science and Industry meets 150 miles southeast of Portland in the Ochoco National Forest. The OSP has a swap meet, guest speakers, vendor displays, and impromptu talks under the night sky. Write to the Oregon Star Party Committee, P.O. Box 91416, Portland, OR 97291, or call Chuck Dethloff at (503) 357-6163, e-mail: dethloff@uofport.edu.

August 15-18 (Franklin, Pennsylvania). The Oil City Astronomical Society holds its annual **Astroblast** under the inky black night sky of western Pennsylvania. Partiers set up around the club's observatory, which houses a remotely controlled 18-inch Newtonian. During the day there are workshops on how to build inexpensive observing accessories. Family activities include hiking, biking, and tours of historic oil country. Contact John O'Hara, P.O. Box 164, Reno, PA 16343, (814) 677-3972.

August 8-10 (Alma, New Brunswick). If you didn't get enough of Atlantic Canada's beauty in June (see Astro-Atlantic '96), then consider **Nova East '96**, a star party in its tenth year put on by the Royal Astronomical Society of Canada's Halifax Centre. Highlights include a swap meet, some impromptu talks, a complimentary corn boil, and observing under New Brunswick's jet black skies. Contact Paul Gray at 108 Aspen Court, Lower Sackville, Nova Scotia B4C 1E1, Canada, (902) 864-2145, e-mail pgray@hercules.stmarys.ca. The party's Web site is http://apwww.stmarys. ca/rasc/rasc.html.

At press time ASTRONOMY could not get information about the **Annual Northwoods Starfest**, Fall Creek, Wisconsin, (contact Ray Forsgren at 715-723-8489) and the **Southern Idaho Regional Star Party** held at Bruneau State Park, Idaho (contact Sam Johnson at 208-939-2095). Both were presented last year from August 25 to 27. □

Patrick Wiggins



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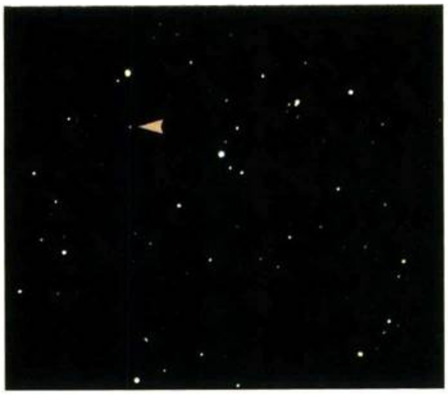

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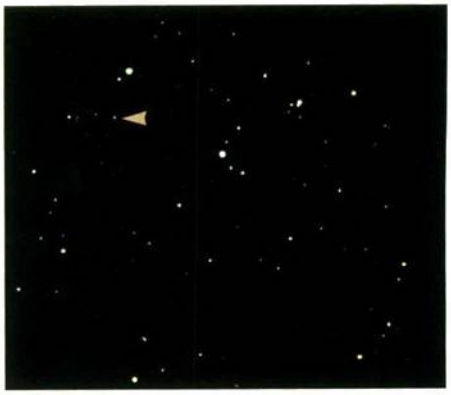

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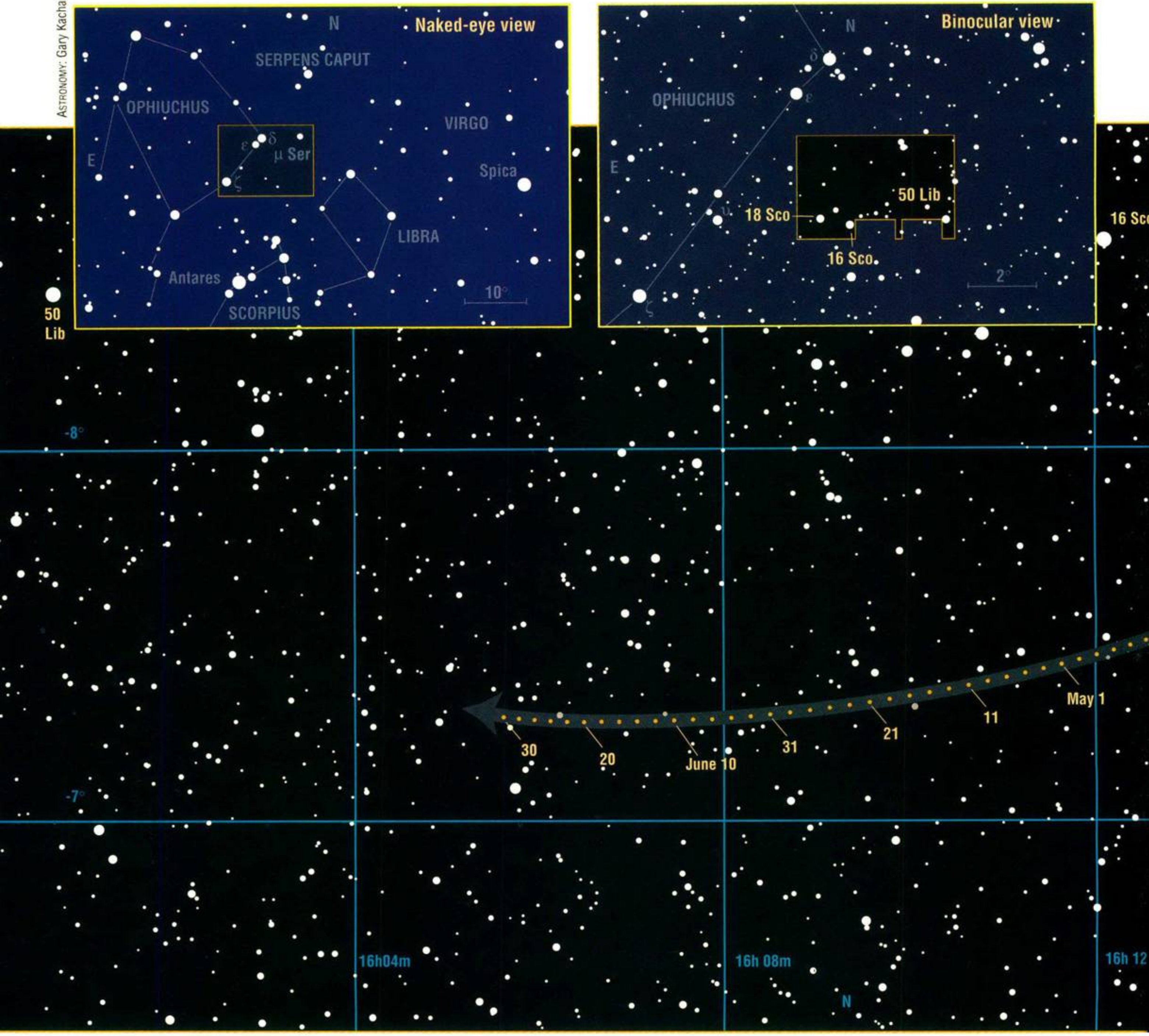
ASTRONOMY: Gary Kachar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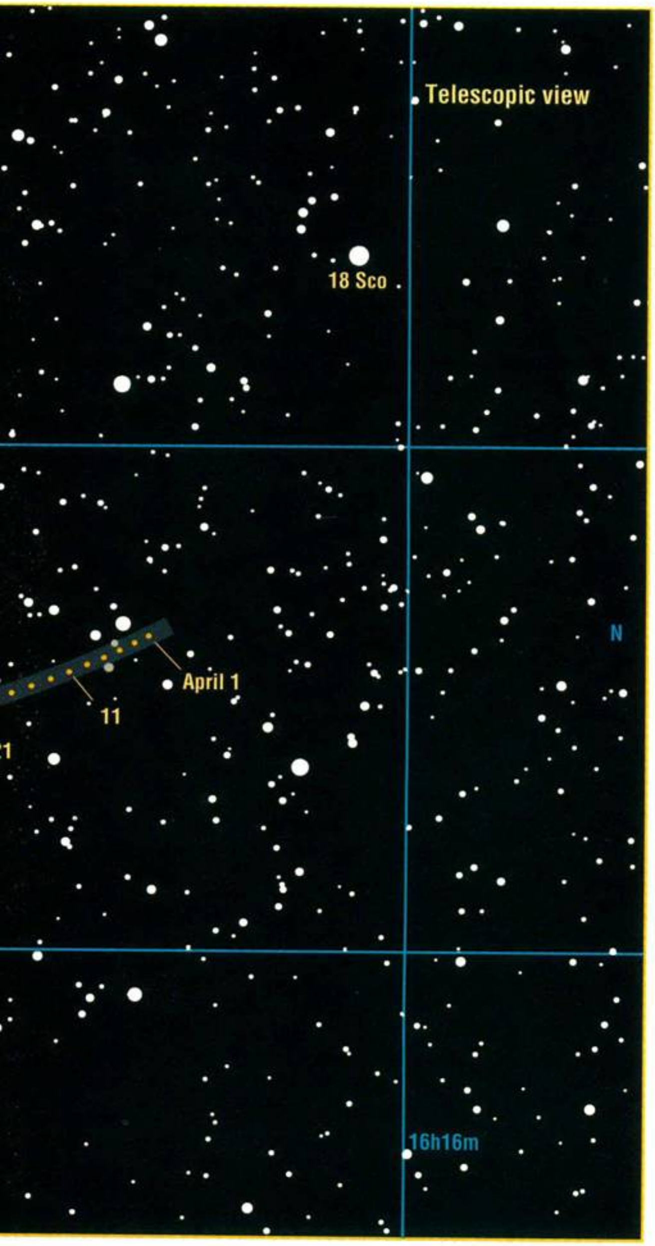
PLUTO

Observing to the Edge

Take a journey to the distant reaches of the solar system, and in the process check off that last planet on your observing scorecard.

by Richard Talcott



Mysterious and alluring, Pluto beckons to backyard astronomers around the globe. Maybe it's because no human eye, or spacecraft, has gazed upon this enigmatic world up close. Our imaginations can run wild as we envision an alien landscape bathed in the soft glow of a faraway Sun.

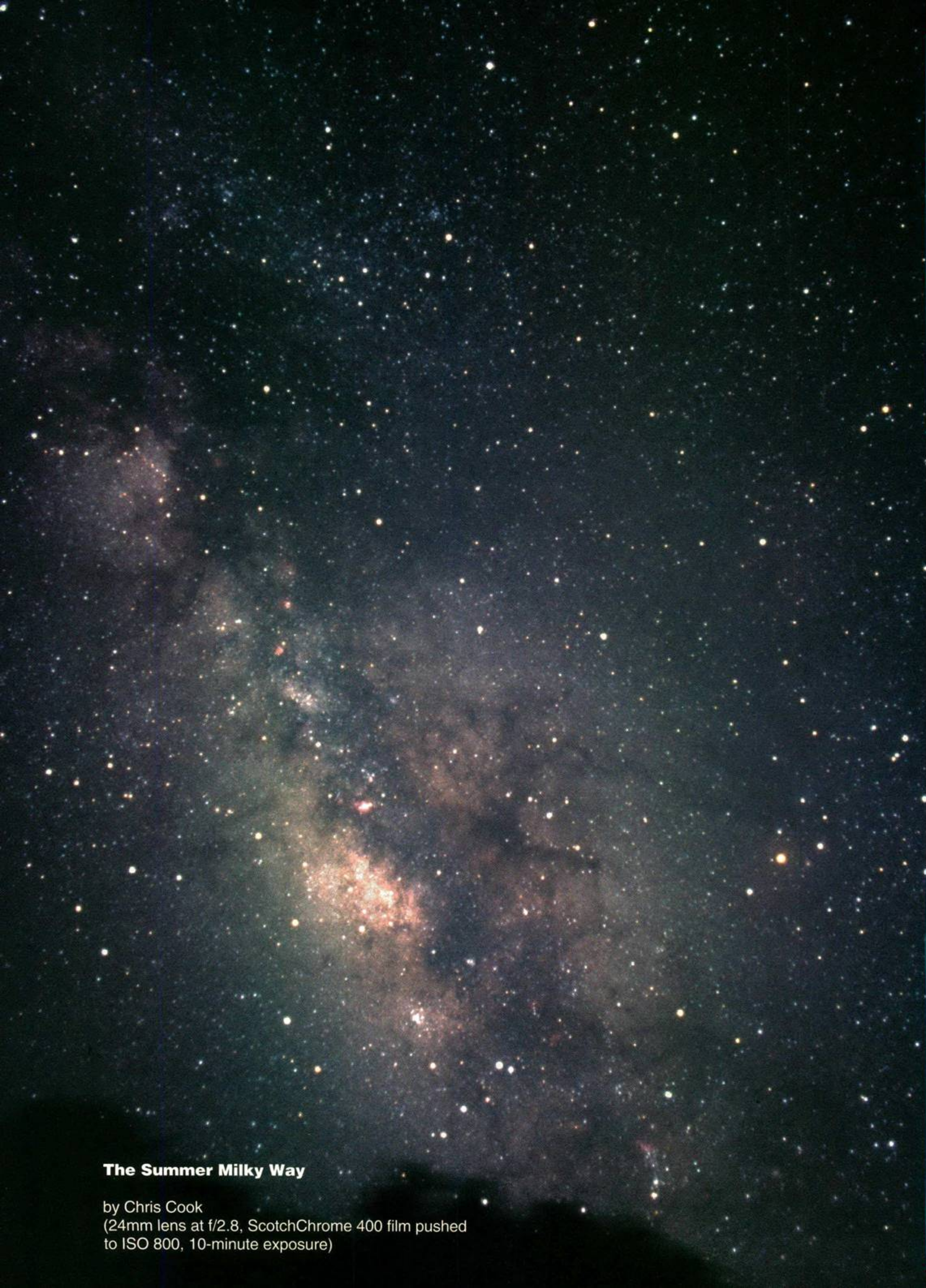
Whatever the reason, few celestial objects appeal to the romance of observing as much as Pluto. During the next few months, you can rekindle that romance by bagging the solar system's outermost planet while it appears at its best for 1996. All you need is the right equipment and the knowledge of when and where to look.

To glimpse the feeble light of the 14th-magnitude planet, you'll want to use an 8-inch or larger telescope. Although experienced observers have glimpsed Pluto in a 6-inch scope under excellent conditions, an 8-inch or preferably larger scope gathers enough extra light to significantly increase your chances of spying it. (To try to discern Pluto's faint satellite, Charon, use at least a 20-inch scope and follow the directions in "Can You Spot Pluto's Moon?" in this month's Sky Almanac.)

Also choose an observing site far removed from the competing lights of the city and a time when the Moon's harsh glare doesn't interfere. The best times come within a week or so of New Moon, which occurs on the 17th of April and May and the 15th of June.

Throughout this period, Pluto treks slowly westward through the part of far western Ophiuchus surrounded by Scorpius, Libra, and Serpens Caput. To find Pluto, first locate the 3rd-magnitude stars Delta (δ) and Epsilon (ε) Ophiuchi, which lie a little over 20° north of Antares, the 1st-magnitude luminary of Scorpius. Then use the binocular chart to zero in on the 5th-magnitude stars 16 and 18 Scorpii about 4° south and a little west of Epsilon. Those two stars serve as the jumping off point so you can star-hop to Pluto's field using the telescopic chart.

This chart shows Pluto's position at 11 p.m. EDT (8 p.m. PDT) from April through June. It includes stars down to magnitude 14.5, so you should be able to discern the point of light that is Pluto from the background stars. To confirm your sighting, however, sketch the field of view in your telescope and return to the same field a night or two later. The dot that has shifted position is Pluto. □



The Summer Milky Way

by Chris Cook
(24mm lens at f/2.8, ScotchChrome 400 film pushed
to ISO 800, 10-minute exposure)

MEET THE MILKY WAY

From naked-eye star clouds to telescopic challenges, the summer Milky Way is a must-see attraction for every skywatcher.

by David J. Eicher

The Omega Nebula

by Jack Newton
(25-inch f/5 reflector, Pictor 1616 CCD camera)

Sure, the summer Milky Way has been sneaking around in the early morning sky for the last couple of months. But now it's centrally placed on the midnight stage, stretching from Scorpius in the south to Cygnus in the north and on around to the slowly rising form of Cassiopeia in the northeast. And its treasures offer something for skywatchers of every level. Naked-eye viewers can bask in the glory of the light from a million stars and trace the black etchings of dark nebulae. Binocular viewers can delight in sprawling open clusters and the fuzzy glow of star factories hard at work. Telescopic observers can return to their old favorite hunting ground to rediscover their past triumphs and log new finds.

No matter how you choose to explore the Milky Way, three great regions dominate it, each moving into view as the night matures. The first marks the center of the Galaxy, populated by the stars of Scorpius and Sagittarius. For North American viewers, this area rests on the southwestern horizon by the middle of the night. Moving northeastward brings into view the second region, one dominated by Scutum, Aquila, Ophiuchus, and Vulpecula. The third region, reaching from overhead to the northern horizon, contains Cygnus, Lyra, Cepheus, Lacerta, and Cassiopeia.

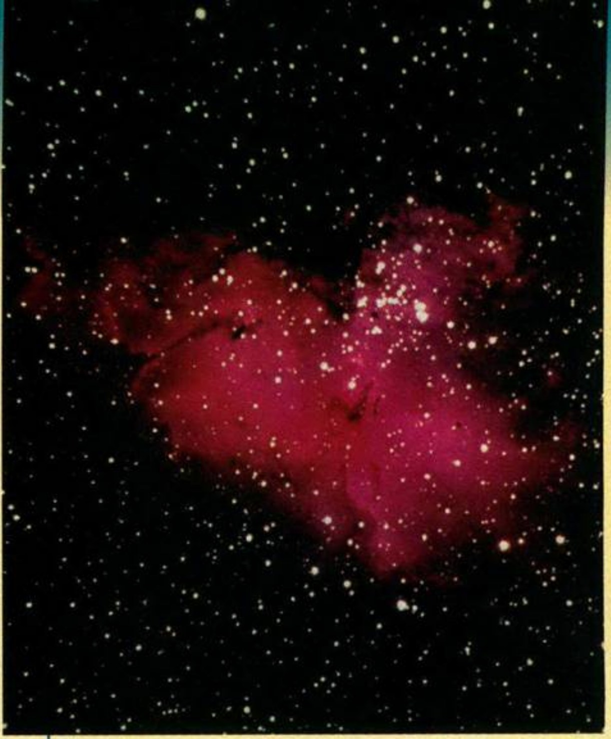
Each of these regions holds dozens of viewing possibilities for the eye, binocular, or telescope. Many of the more alluring sights are those not constantly visited. In the first region, among the lesser known targets is a complex of reflection nebulosity southeast of the globular star cluster **NGC 6723** in Corona Australis, below the Teapot-shaped form of Sagittarius. Viewing this area with large binoculars or low-power telescopes conveys the Milky Way's three-dimension-

Globular Cluster NGC 6723 and Reflection Nebulae

by Luke Dodd
(4.7-inch f/6 refractor, hypersensitized Fujicolor 400 film, composite of two 60-minute exposures)

The Galactic Dark Horse

by Ronald E. Royer

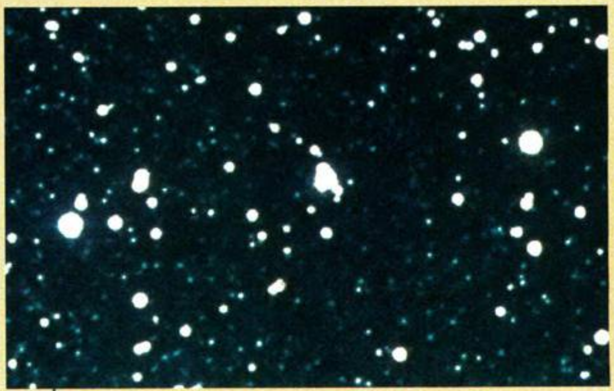


The Eagle Nebula

by Jason Ware
(16-inch SCT, hypersensitized Fuji HG 400 film, composite of two 60-minute exposures)

The Dumbbell Nebula

by Jack Newton
(25-inch f/5 reflector, Pictor 1616 CCD camera)



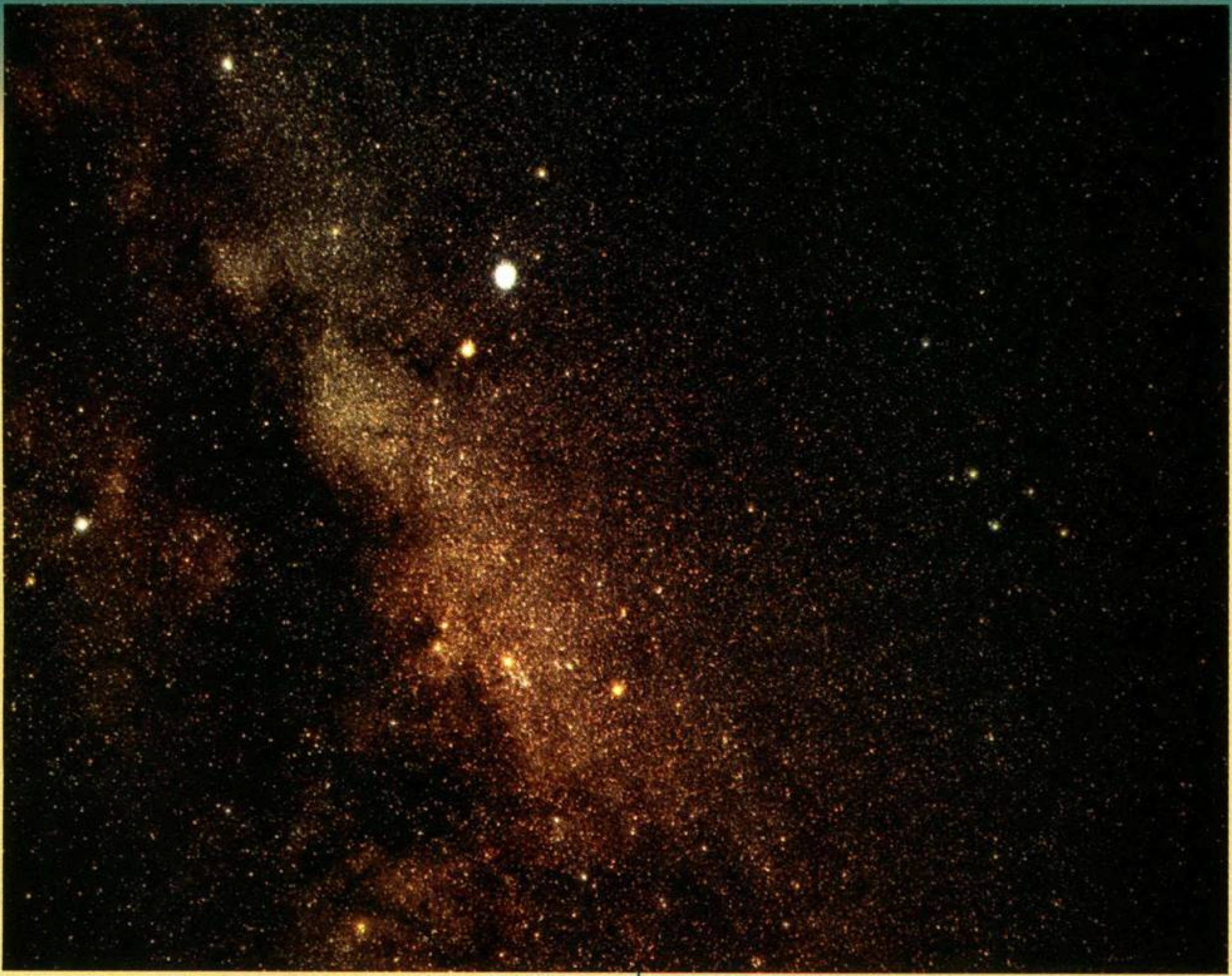
Planetary Nebula NGC 6804

by Jack Newton
(16-inch f/5 reflector, 18-minute exposure)

ality. The bright stars in the field include Gamma and Epsilon Coronae Australis, which lie 70 and 100 light-years away, respectively. The reflection nebulae **NGC 6726/7** and **NGC 6729**, southeast of the globular, surround infant variable stars called T Tauri stars; their distance is approximately 800 light-years. The distance to the deep background object, the globular cluster, is about 28,000 light-years.

North of the Teapot, in the star-studded spine of the Milky Way stretching through Sagittarius and Serpens Cauda, are two emission nebulae, each busily producing young clusters of new stars. Visible barely to the naked eye, the **Omega Nebula** (M17) and **Eagle Nebula** (M16) are fuzzy clumps of gray-green light in binoculars. Telescopes show them as complex regions littered with mist and faint stars. The Omega is the closer of the two, lying 5,000 light-years away. Its high surface brightness means the nebula's distinct bar-shaped glow stands out well in small scopes. The Eagle, at the less neighborly distance of 8,100 light-years, is famous most recently for the stunning set of Hubble Space Telescope images showing its dusty "star pillars." The dark columns are revealed against the faint glow of the gas in 8-inch and larger scopes.

To the naked eye, the overwhelmingly brightest and most attractive area lies in this direction of Sagittarius and Serpens. This is roughly in the direction of the galactic center. Yet naked-eye observers can also note a tremendously bright star cloud in the second region, centered on the small star group Scutum and made visible by outlines of dark nebulosity. This is the **Scutum Star Cloud**, home to a brilliant open cluster called M11, nicknamed the **Wild Duck Cluster**. (The 19th-century observer William Henry Smyth compared the cluster's myriad stars to a flight of wild ducks.) Perceptive naked-eye observers will not only

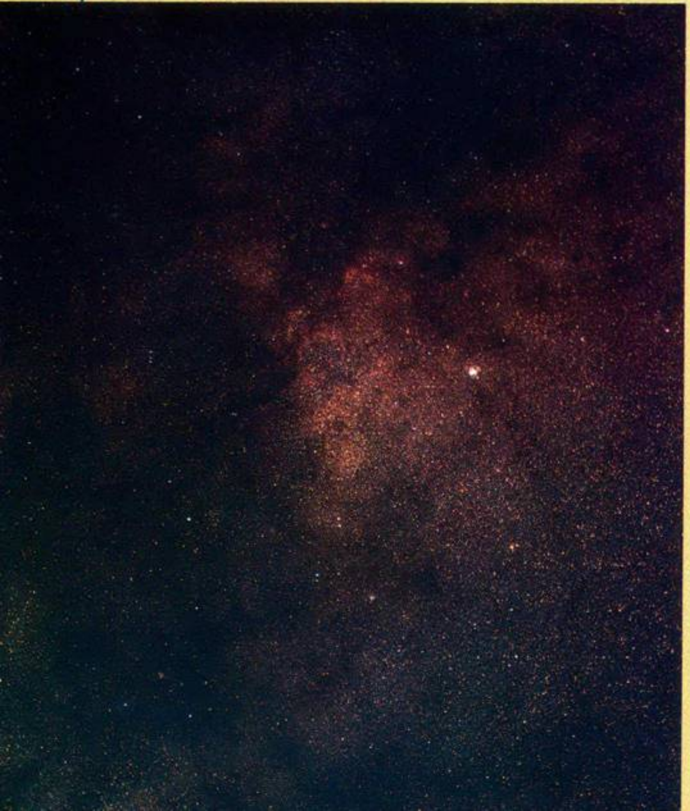


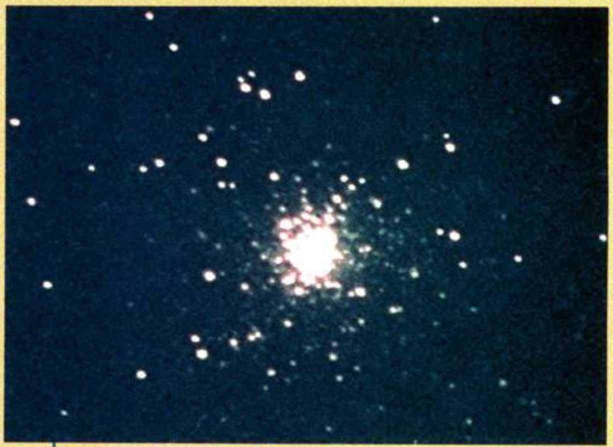
Aquila, Delphinus, and Sagitta

by Luke Dodd
(105mm lens at f/3, hypersensitized Fujicolor 400 film, composite of two 20-minute exposures)

The Scutum Star Cloud and M11

by Ronald E. Royer





Globular Cluster M10

by Flavio Borgna
(8-inch f/10 SCT, ScotchChrome 800 film pushed to ISO 1600, 20-minute exposure)

Giant Emission Nebula IC 1396

by George Greaney
(6-inch f/7 refractor, hypersensitized Fuji Super HG 400 film, composite of two 50-minute exposures)

The Cygnus Star Cloud

by John Volk
(105mm lens at f/2.4, Fuji Super HG 400 film, 55-minute exposure)

Emission Nebula IC 1848

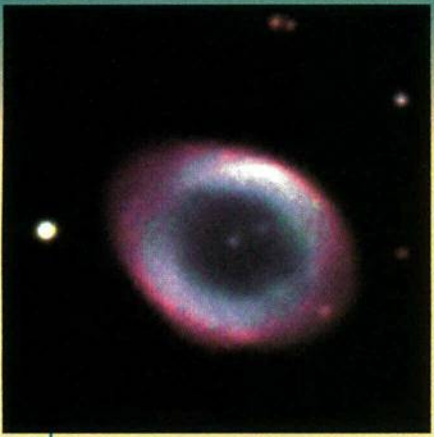
by Michael Stecker

explore the macrostructure of the Star Cloud, but on dark nights will spot the Wild Duck as a tiny spot near the cloud's northern edge.

Shifting southwestward into Ophiuchus brings another naked-eye spectacle into view, the **Galactic Dark Horse**. This network of channels of dark nebulosity forms a horse-shaped figure that spans 15° and is centered on a spot between Theta and Xi Ophiuchi. On a dark night, low-power binoculars will show much of the outline of this looming figure. North of the Dark Horse, in central Ophiuchus, lies a much overlooked globular cluster. **M10** (NGC 6254) is too faint to spy with the naked eye, but binoculars show it as a compact spot of misty light. A low-power telescope reveals the fuzzy disk of half a million stars.

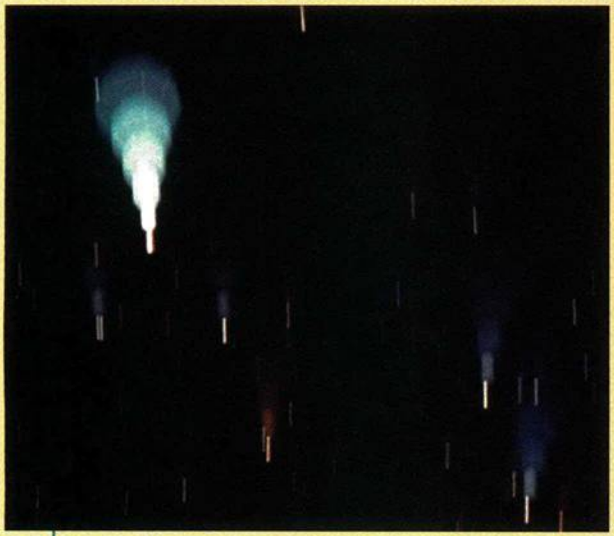
Two more constellations in the second group, Aquila and Vulpecula, are famous for their planetary nebulae. These objects are the (relatively) short-lived byproducts of dying stars, shells of puffed-off gas that dissipate into the Galaxy's winds over the course of 20,000 to 50,000 years. One of the prettiest is Vulpecula's **Dumbbell Nebula** (M27), an object that, in a small telescope, sports two prominent lobes of gray-green light. This shell of a former star requires binoculars to be seen, and large ones at that. At its distance of 1,000 light-years, it appears pretty small. Its diameter is 1⁄5 that of the Full Moon. Quite a contrast is offered by Aquila's **NGC 6804**, one of many planetaries in the V-shaped constellation. This ring-shaped nebula lies four times more distant than the Dumbbell, making its magnitude a ghostly 12.2 and its diameter only 1⁄100 that of the Moon. This object is a challenge for telescopes in the 8- to 10-inch range — using one, can you spot the nebula's 14th-magnitude central star?

Moving into the third, northernmost, region of the summer Milky Way brings into view the commanding constellations Cygnus and Lyra. Yet another planetary



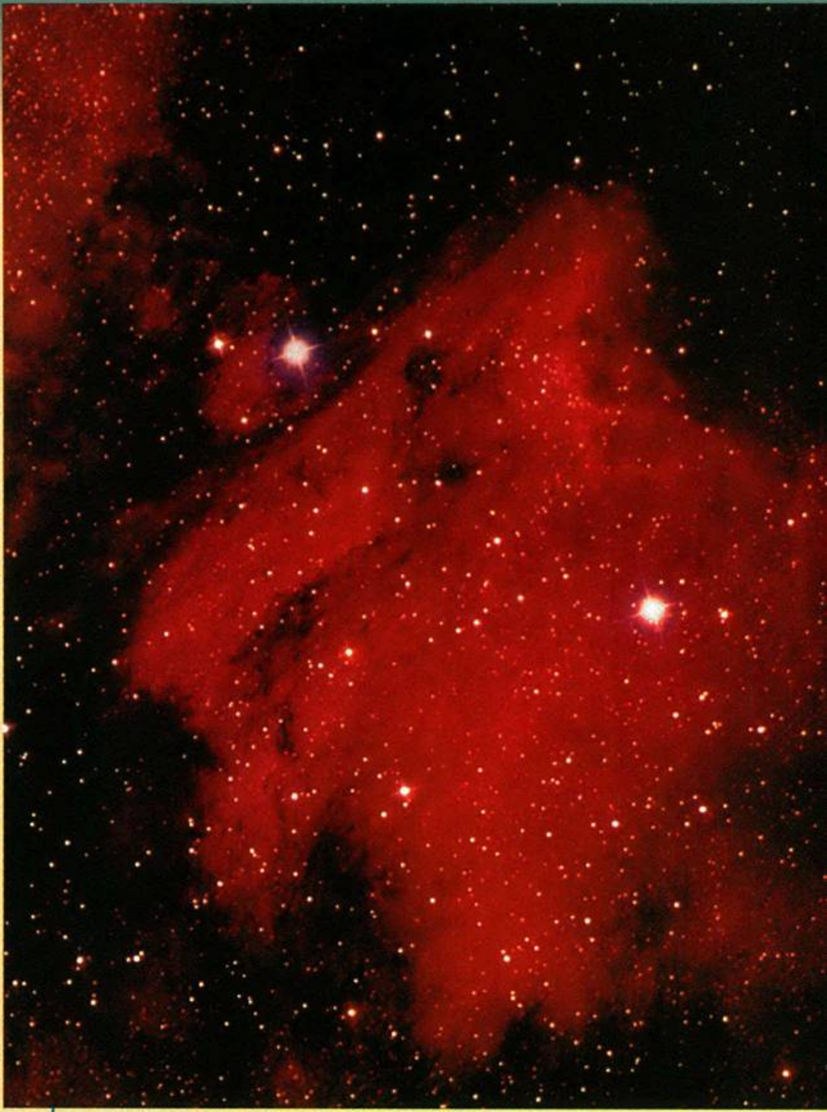
The Ring Nebula

by Giovanni dal Lago
(11-inch SCT at f/5, Starlight Xpress CCD camera, eight 40-second integrations)



Star Colors in Lyra

by Mansfield Clinnick
(135mm lens at f/2, Kodak Royal Gold 1000 film, 2-minute exposures stepped over six intervals)



The Pelican Nebula

by Bill and Sally Fletcher
(8-inch f/4.5 reflector, hypersensitized Tech Pan film, tricolor image from 65-minute green, 90-minute blue, and 125-minute red exposures)

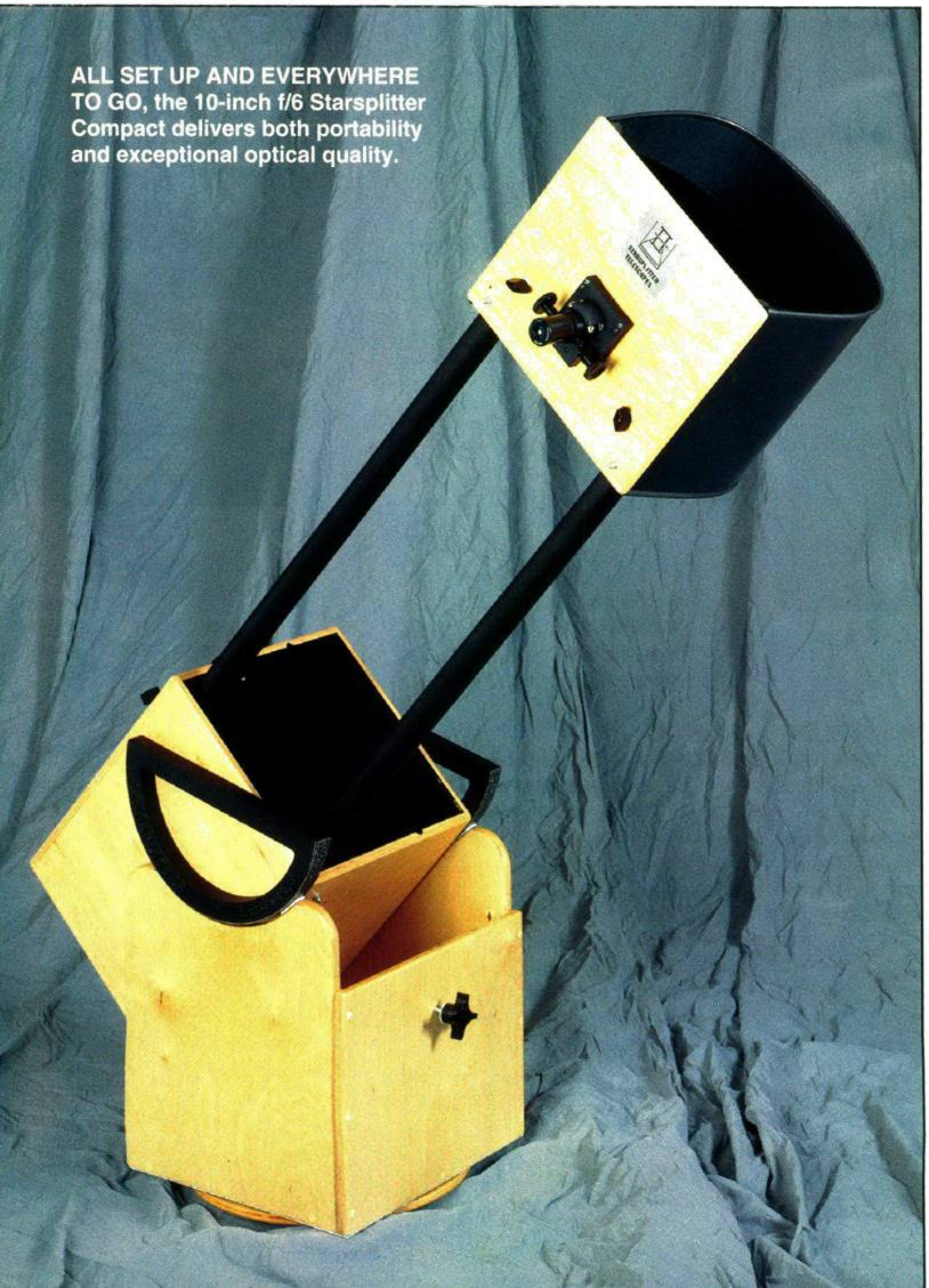
nebula can be found between Beta and Gamma Lyrae — the **Ring Nebula** (M57). This most observed of all planetary nebulae lies twice as far away as the Dumbbell and because of its small size requires a telescope to enjoy. Its appearance is strikingly like that of a smoke ring.

In nearby Cygnus, try a more challenging sight for the naked eye or wide-field binoculars. The **North America Nebula** (NGC 7000), a huge emission nebula near Deneb (Alpha Cygni) is relatively easy to spot with the eye alone under a dark sky. But the **Pelican Nebula** (IC 5067–70), a fainter portion of glowing gas detached from the North America by dust lanes, is more challenging. Two more large emission nebulae offer good visual challenges to naked-eye observers: **IC 1396**, a large, circular glow defined well by dark nebulae and lying south of the orange star Mu Cephei; and **IC 1848**, a roughly rectangular cloud of stars and nebulosity in Cassiopeia, several degrees northeast of the famous Double Cluster in Perseus.

Well, there you have it. The Milky Way's back, and along with thousands of other backyard astronomers this year, you'll go out to meet it on many a clear night. Be sure to return to old friends and look at them with a fresh eye, but also take out your atlases and explore some new and unusual objects. That personal sense of discovery, renewed each year in the warm summer air, will offset with priceless memories the bleary eyes you have the next day. □

David J. Eicher is an associate editor of this magazine and has long been a fan of galaxies — our own and others.

The Starsplitter Compact



ALL SET UP AND EVERYWHERE TO GO, the 10-inch f/6 Starsplitter Compact delivers both portability and exceptional optical quality.

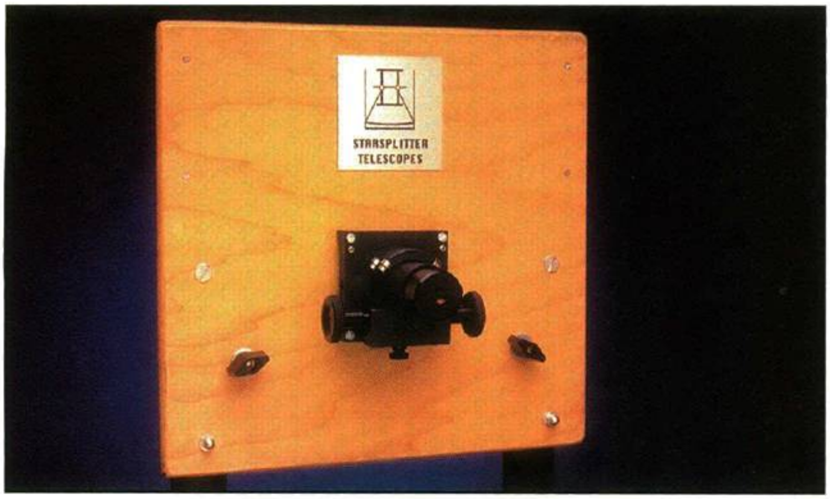
Want to travel light and set up quickly? Check out this remarkably portable Dobsonian telescope.

by John Shibley

Commercial Dobsonian design has settled into full maturity. What is there to optimize or improve upon in what is already an elegantly simple design? How about making Dobsonians even more portable? This would benefit most observers, for whom getting to a dark site usually means packing all the important items needed for an observing session — not the least of which is a telescope — into a small car.

Starsplitter Telescope's Jim Brunkella acknowledges this 1990s reality by introducing his Starsplitter Compact telescopes. The line includes an 8-inch f/6, a 10-inch f/6, a 12.5-inch f/5, and a 14.5-inch f/5. I put the 10-inch f/6 Starsplitter Compact through its paces and found it offered everything a simple Dobsonian promised, along with exceptional portability.

The Compact line-up embodies a traditional Dobsonian's rugged and straightforward design philosophy, but goes one step further. It cuts the number of truss tubes needed to support a secondary assembly down to two and stashes



MOUNTED IN THE SECONDARY BOARD is a black, anodized aluminum focuser that accepts 1 ¼-inch eyepieces. Black hand knobs tighten J-bolts that secure the board to the trusses.

that assembly inside the primary mirror box for storage and transport. This effectively reduces the number of pieces you need to pack and carry to three: The mirror/rocker box combination, two aluminum trusses, and a flexible glare shield. The heaviest component, is the rocker/mirror box which amounts to 35 pounds in the 10-inch's case.

Laying a Stable Foundation

Three components make up the lower part of the Starsplitter Compact: a mirror box that houses the primary mirror in its cell; a rocker box, into which the mirror box slips; and a ground board, on which the rocker box pivots left and right. All three pieces are made of furniture-grade, ½-inch Apple-ply plywood glued using tongue-in-groove joints at the corners. All surfaces are sanded smooth and sealed to resist moisture. Only the mirror box's interior is painted flat black to reduce incidental glare.

The mirror box has a closed bottom, so purists may fault its ability to ventilate the mirror to ambient temperature. I found, however, its 1 ½-foot depth proved adequate for air to circulate around the mirror and cool it down, while providing enough protection from dew.

Bolted on either side of the mirror box are cast aluminum bearings one foot in diameter. These support the mirror box after it slides into the rocker box. The bearings also allow the scope to pivot in altitude. To make this motion smoother, a type of Formica called Ebony Star lines the bearing surfaces that come into contact with the rocker box. These contact points take the form of two evenly spaced Teflon pads. Years ago, amateur telescope makers found the combination of Ebony Star's bumpy face and Teflon's smooth surface yielded the right amount of "sticktion," a state between slipperiness and friction that lets a scope pivot smoothly yet hold its orientation without slipping when you let go.

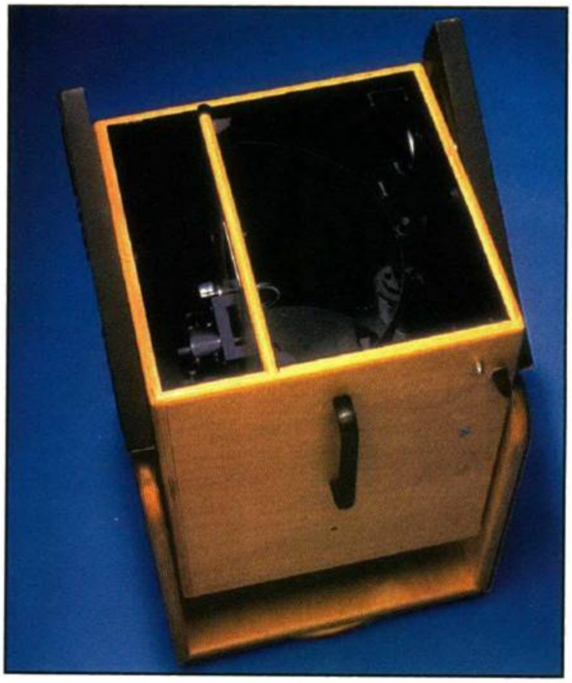
The scope's ability to pivot in azimuth is built into where the rocker box joins a ¼-inch-thick ground board. A single quarter-inch nut and bolt functions as an axle and holds the two together. The rocker box's underside is of white Formica with a surface that's a bit more bumpier than Ebony Star. This surface rides on the ground board's three Teflon pads. Each pad is positioned directly above three ½-inch-thick, laminated wood blocks that touch the ground.

The entire rocker/mirror box and ground board assembly comes from Starsplitter pre-assembled in one shipping container. Nested inside the mirror box is the secondary board, which slides into the mirror box. This is how the secondary stows for storage and transport. A lid with a wooden knob caps the mirror box when the scope is not in use.

Another shipping box contains the primary mirror already mounted in its cell. The black, ½-inch plywood cell supports the mirror at nine places on cork pads. Three metal clips evenly spaced around the mirror's circumference secure it against these pads in the cell.

After unpacking the mirror from its shipping box, it's time to install the mirror and its cell into

THE SCOPE'S SECONDARY BOARD slides on grooves into the mirror box for storage and transport. A wooden lid caps the box to keep dust out.



the mirror box. Three machine screws that stick out the plywood cell's backside match up with three holes drilled through the bottom of the mirror box. With the cell in place, the screws continue out the bottom of the mirror box to accept three hand nuts that tighten the cell down.

Rubber O-rings on each screw sandwich between the cell and mirror box. Compressing these rings lets you collimate the primary mirror. Tightening or loosening a hand nut makes the O-ring compress or expand. An expanding O-ring raises its portion of the mirror cell. Consequently, collimation merely involves tightening or loosening one or several hand screws until the scope's mirror is properly aligned.

When I collimated this scope on cool evenings, I found a slight lag between the time a nut was loosened and when the cell responded. In all instances the rubber rings eventually did "relax" within seconds after loosening. The bottom line is to take your time if you ever have to collimate on nights colder than 32° F.

Up with the Trusses

Starsplitter Compact's two aluminum trusses ship in a third package. These black-anodized, 1 ½-inch diameter tubes support the secondary board, with its diagonal mirror and focuser. They place the board a proper distance from the primary mirror.

Installing them is the same every time you go out into the field. Each truss snugs into the mirror box on metal guide tracks. The tube stays in place by J-bolts tightened down with hand knobs. The secondary board connects in much the same fashion: the trusses butt against guide tracks and are held down by tightened J-bolts.

This aspect of the assembly process proved awkward no matter how many times I went through it. In order to accept the trusses, the J-bolts have to be loosened to a point where they flop around and get in the way. This becomes tricky when you're trying to simultaneously hang on to and install the secondary board. Oftentimes I found myself wishing for a third hand to steady the board while I maneuvered each J-bolt around a truss before tightening it down. At best, the whole operation is a test of dexterity. But with a little practice, the process did seem to get easier. Besides, when all is said and done, the trusses tighten down for rock-solid stability.

Starsplitter ships the Compact's secondary mirror and its stalk in a separate box. Both install quickly and easily with one nut: The threaded stalk slips into the secondary board's curved support vane and bolts into place. It's a good idea to do this initial installation before placing the secondary board on trusses. That way if you should drop the nut or fumble the secondary mirror, there's no risk of damaging an exposed primary mirror. Once the secondary mirror is attached, you never have to remove it.

Starsplitter's secondary mirror and holder are made by AstroSystems. The secondary's adjustment screws require an Allen wrench to work. However, once the secondary mirror was pivoted and aligned properly, I never had to touch it again.

The Compact's final component, a flexible dew shield, comes shipped with the mirror/rocker box. The glare shield attaches to Velcro tabs glued on either edge of the secondary board. The board's interior side is also flat black to reduce glare and stray light that ruins image contrast so necessary to deep-sky observing.

Under Star-splashed Skies

I took the 10-inch Starsplitter Compact out under the sky on three occasions under varying degrees of temperature and humidity, from late August through early November. For

STARSPLITTER COMPACT

Standard Specifications

- Aperture:10 inches (254 mm)
- Focal ratio: f/6
- Focal length: 2540mm
- Secondary size (minor axis): 1.83 inches
- Secondary obstruction (by diameter): 18%
- Finder: Telrad and base
- Total telescope weight: 40 lbs.
- Weight of heaviest component: 35 lbs.
- Eyepiece height at zenith: 5 feet
- Manufacturer-direct price: $999
- Promised delivery date: 4 weeks

Accessories

Telrad and base: $40
2-inch focuser: $100

Other Models

8-inch f/6: $799
12.5-inch f/5: $1499
14.5-inch f/4.5: $1999

Starsplitter Telescopes, 3228 Rikkard Drive,
Thousand Oaks, CA 91362, (805) 493-2489

each junket, the scope fit smartly into the front passenger side of my 1987 Chevy Nova. Once at the observing site, it assembled in less than five minutes.

This first evening was moderately warm and muggy, a night when the Compact's open truss design made the primary and secondary mirrors especially prone to dew. Conventional, less portable multi-truss Dobsonians usually incorporate a shroud that slides over the scope's frame to shield its optics. Compact's two-truss design doesn't allow this. That said, dealing with dew is as simple as running a blow dryer every ten minutes or so to keep the optics clear. Starsplitter Compact's two-truss portability more than offsets this periodic inconvenience.

Optically, the Compact 10-inch f/6 performed like a champ. The primary's thickness is a whopping 1 ¾-inches, a full-thickness mirror in anybody's book. I was concerned that such a hunk of glass, even if it is low-expansion Pyrex, would take a considerable amount of time to cool down to ambient air temperature, especially on a cool fall evening. After moving from a 70° F car into a brisk 31° F night, the optics took about 20 minutes to stabilize and yielded distortion-free images. Compact's open design hastens this process, and without the annoying currents found in most tube designs.

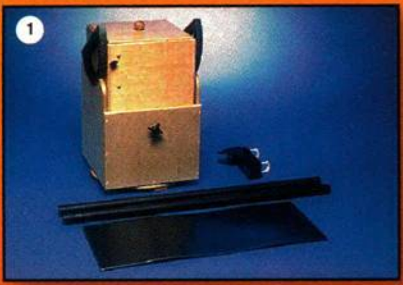
After things cooled down, it was time to star-test the mirror. The mirror, made by Nova Optics, showed no sign of astigmatism. Images on either side of focus showed clean, virtually identical diffraction rings, a sure sign of being spherical aberration-free. In every instance, images snapped into sure focus. Enhanced aluminum coatings applied by QSP Optical to the primary mirror added to this clarity by producing a snappy image contrast.

The scope also performed well mechanically. Both the altitude and azimuth axes turned smoothly regardless of the humidity or temperature. The Compact never sagged in azimuth, even under the weight of a 16-ounce 13mm Nagler eyepiece in the focuser. Beyond this ease and stability of operation, there's a certain amenity that comes from observing with a 10-inch f/6 scope. Eyepiece height when viewing at zenith is a manageable five feet. And the 10-inch Compact's f/6, middle-of-the-road focal ratio provides attributes found in faster rich-field scopes while preserving the option for higher power normally afforded by telescopes f/10 or higher.

Coupled with its portability, all these factors add up to a well thought-out and crafted telescope. In this day and age where pursuers of the deep-sky have been reduced to observational nomads, the Compact may be a godsend. If you're such an observer, the answer to your prayers could take the form of a Starsplitter Compact. ☐

Associate Editor John Shibley frequently distances himself from metro-Milwaukee's abundant dome of light pollution to observe through a variety of telescopes.

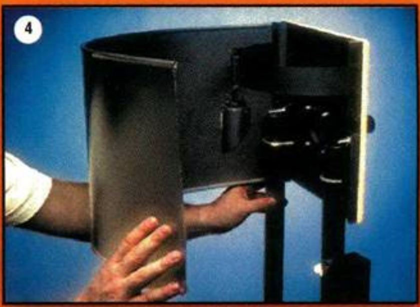
Starsplitter Compact Comes Together . . .



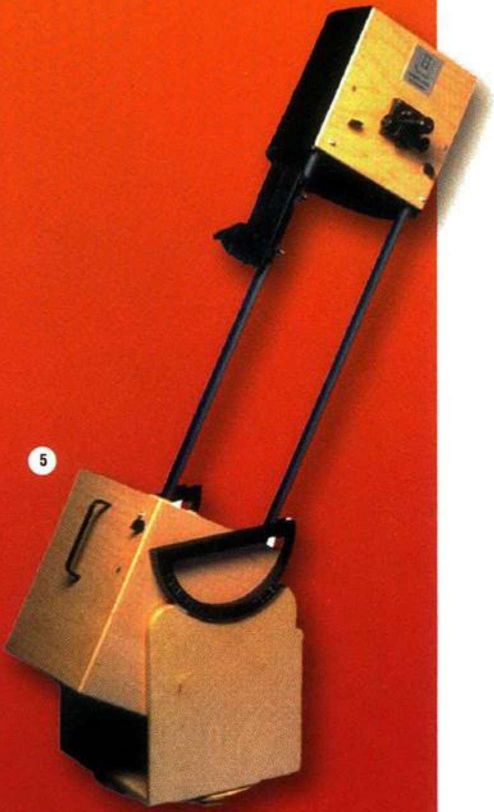
Starsplitter Compact (with its optional Telrad Finder) laid out for assembly.

Tighten trusses into mirror box.

Slip the secondary board onto trusses and tighten.



Install the glare shield.

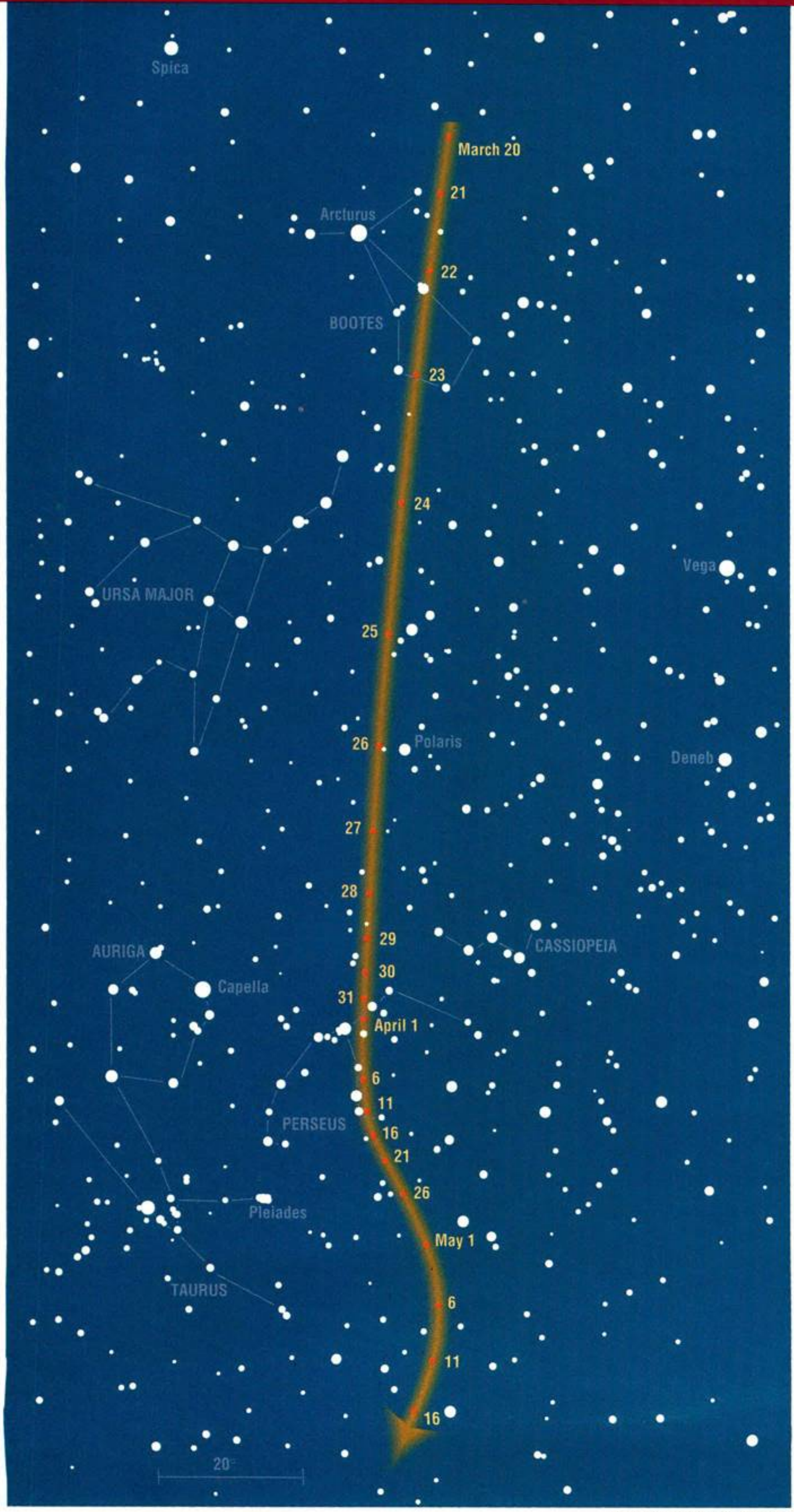


Observe!

How big, bright, and beautiful will Comet Hyakutake be? Nobody knows. That's what makes this . . .

A COMET CRAP SHOOT

by Jeff Kanipe



ASTRONOMY: Katherine Kolstedt

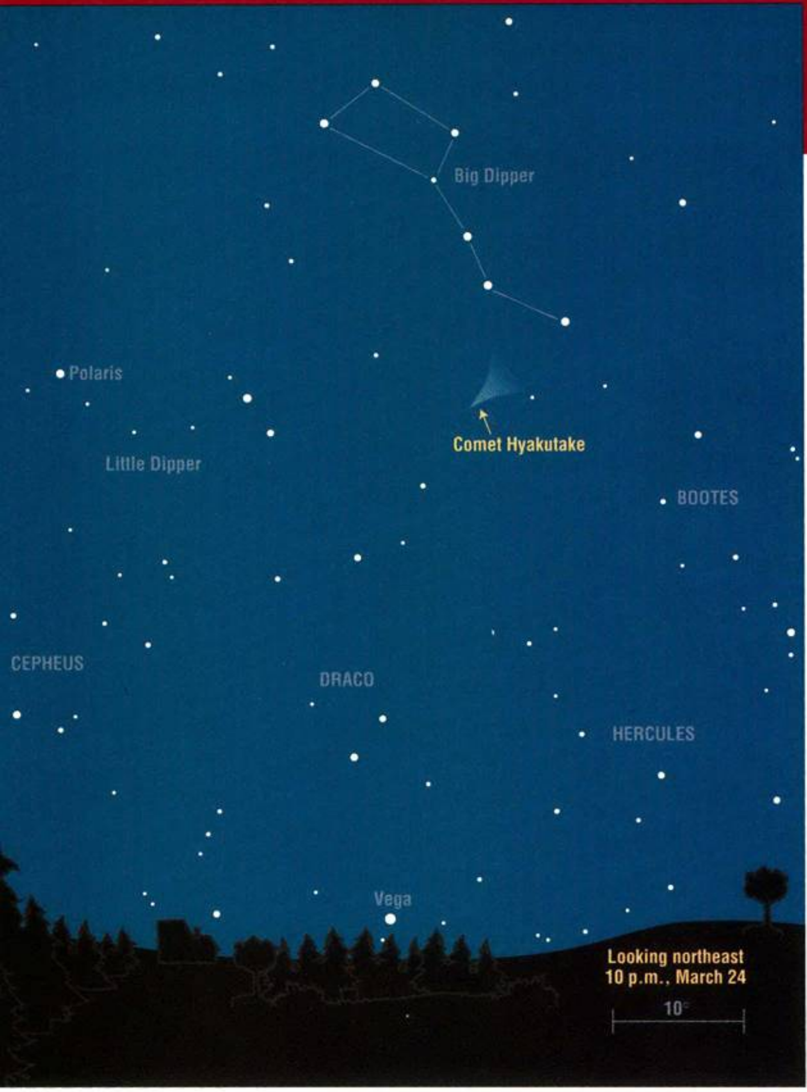
You never know what the universe is going to throw at you. Originally, this article was supposed to help readers find Comet Hale-Bopp as it reaches binocular brightness. We still talk about Comet H-B (opposite page) but we preempt it just a little to discuss news of another comet that we think may put on a respectable show of its own in late March and early April

On January 30, Japanese amateur Yuji Hyakutake, using 25x150 binoculars, made his second comet discovery in 36 days. Designated 1996 B_2, the magnitude 11.5 comet was on the border between Hydra and Libra moving north. Additional observations in early February showed that on March 24/25 the comet would pass within 15 million kilometers of Earth. (See horizon diagram opposite page.) Before then, however, it would reach naked-eye brightness.

Our star map (left) traces Hyakutake's wending path though the north circumpolar region. Two evenings after its closest approach to Earth, the comet lies a little more than 3 degrees from Polaris and is at its brightest, at least magnitude 1. That last week of March, Hyakutake races between Camelopardalis and Cassiopeia, crossing into northern Perseus by April 1.

The first week of April, the comet is circumpolar and should be visible all night. Right after sunset, it appears very low above the northwestern horizon, and sets by late evening. Then, it rises in the northeast about 90 minutes before sunrise. It appears to hang in this part of the morning sky for a couple of weeks. Its southerly motion, however, carries it ever closer to the Sun and thus nearer the sunrise point.

Because the comet is heading more or less in Earth's vicinity, its coma will appear large, perhaps as much as ½-degree in diameter. What it gains in apparent size, however, it loses in apparent brightness. To most people in the city and suburbs, the comet, even at its peak, may be slightly


Big Dipper
Polaris
Little Dipper
Comet Hyakutake
BOOTES
CEPHEUS
DRACO
HERCULES
Vega
Looking northeast
10 p.m., March 24
10°

ASTRONOMY: Katherine Kolstedt

COMET HYAKUTAKE as it appeared in mid-February. Photo by Tim Puckett taken with an ST-6 CCD camera, a 12-inch f/7 SCT, and an 8-minute exposure.

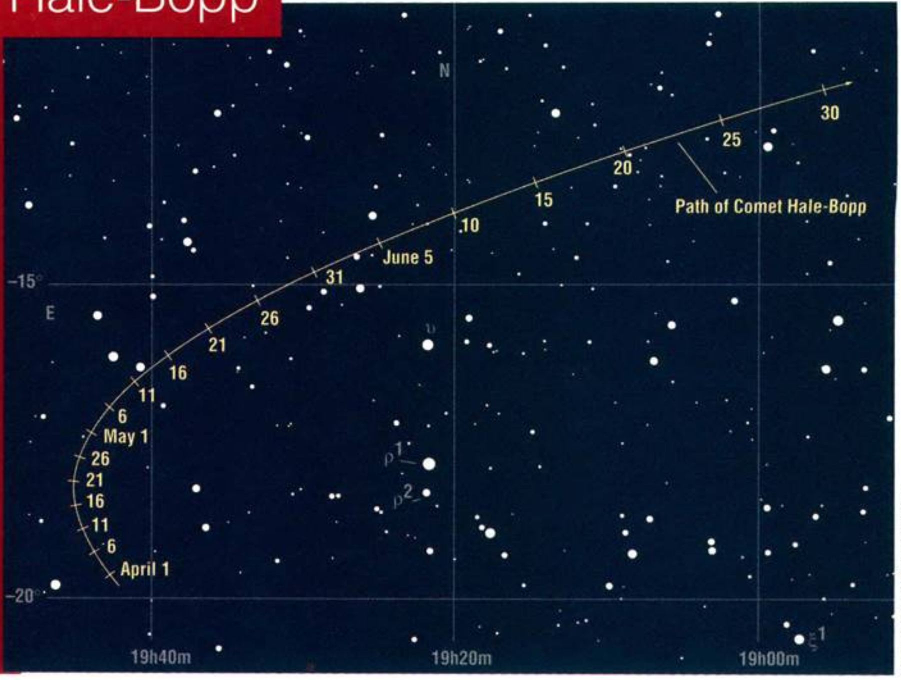
brighter than the brightest star cloud of the Milky Way. It's tail, though it may stretch tens of degrees, will appear more tenuous.

After rounding the Sun in early May, Comet Hyakutake drops off into southern skies, out of view for those in the Northern Hemisphere. By mid-June, well on its way back into the deep freeze of space, Comet Hyakutake will be just a memory. But it will have served well as a worthy prelude to Comet Hale-Bopp. □

Jeff Kanipe is ASTRONOMY's managing editor.

Onward and Upward, Hale-Bopp

Hale-Bopp spends most of April, May, and June nestled in northeastern Sagittarius in the southeast before dawn during early spring. The opening weeks of April find the comet around magnitude 8, teetering on the brink of visibility in 7x50 binoculars. By the time June wraps up, the comet becomes an easy binocular target, shining at magnitude 6.3. At that time, observers working under dark, haze-free skies might get humanity's first glimpse of Hale-Bopp with the naked eye.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Path of Comet Hale-Bopp
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ρ2
ξ1
19h40m
19h20m
19h00m

ASTRONOMY: Phil Kirchmeier

Giant comet Hale-Bopp is heading toward a rendevous with Earth in the spring of 1997. It will be at its most spectacular–perhaps 100 times brighter than Halley's Comet–in March and April.

In fact, if Hale-Bopp lives up to expectations, it is likely to become one of the brightest comets seen in a generation.

Don't miss out. Join *Sky & Telescope* and Scientific Expeditions aboard Holland-America's beautiful new *Veendam* on the 7-day cruise, March 30, 1997, sailing from Ft. Lauderdale to view this rare visitor from the pitch-black skies of the Caribbean. Our ocean-going hotel will maneuver to find clear skies at the optimum time for viewing before dawn or after sunset. Book now–space is going quickly. For a free brochure and more information, call

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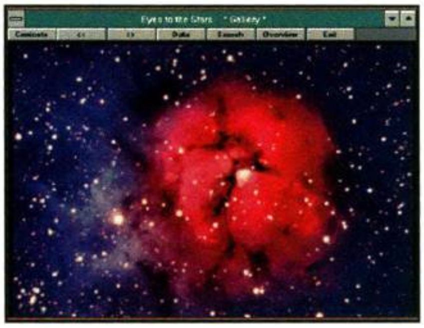
Astrophotography How-to



Eyes to the Stars

Wolf 359, P.O. Box 138, Kinburn, ON K0A 2H0, Canada, (800) 823-0183, (613) 839-5304. Price: $49.95 plus $5 shipping (U.S. funds); $67.25 plus $5 shipping (Canadian funds; GST and PST not included). Minimum requirements: 80386-based computer, Windows 3.1 (Windows 95 compatible), double speed CD-ROM drive, and Super VGA graphics.

The collection of more than 600 images of planets and deep-sky objects taken by 58 astrophotographers alone justifies the price of this CD-ROM. But *Eyes to the Stars* also contains guidebooks to equipment and techniques so beginning and intermediate astrophotographers can learn how to take stunning images.

Other sections present the history of observational astronomy, slide shows, and movies. The slide shows are divided into solar system objects, deep-sky objects, Messier objects, CCD images, and alien worlds. The movies include visions of Mars, a Moon tour, imaging Jupiter and Io, and a grand tour of the cosmos.

The movies and slide shows incorporate the 600-plus astroimages, but users can view the images separately within the photo gallery section. Data sheets for each image provide information about who took it and what equipment was used, as well as comments from the contributors.

Also included on the disk is demonstration software. Sehgal Corp. provided a demo version of the Hidden Image image-processing program, and Electrim and SBIG shared copies of their CCD camera software.

MPO96

BDW Publishing, Box 818, Florrisant, CO 80816, phone/fax (719) 748-8083, e-mail 71511.515@compuserve.com. Price: $19.95 plus $4.05 shipping in the U.S., $9.05 shipping for foreign airmail. Minimum requirements: 80386SX-based computer, Windows 3.1 4 MB of memory, CD-ROM drive, mouse, and VGA graphics.

Asteroid observers are familiar with the *Minor Planet Observer*, a monthly newsletter produced by BDW Publishing that contains finder charts, tables of positions and brightnesses, orbital elements, and other asteroid news. Now BDW has gathered all this information together on a single CD-ROM for the entire year. *MPO96* contains 2,300 finder charts for asteroids reaching magnitude 14.5 or brighter, a database of 6,535 asteroids, and search engines for determining the best times to observe the minor planets.

A browser database permits indexing by name, number, or orbital elements. The discovery database lists asteroids by number, name, designation, discoverer, and date of discovery. An opposition database tabulates date of opposition, magnitude, date and distance at closest approach to Earth, and date and magnitude at its brightest.

Two search engines tell when an asteroid will be at a particular altitude and azimuth or near a particular right ascension and declination for astrophotography. In addition, *MPO96* lists appulses with stars and deep-sky objects, conjunctions with planets and stars, and Sun and Moon positions.

The finder charts have several scales available and permit users to flip east/west and north/south, zoom in for printing of a specific area, and invert the color scheme to print black-on-white or white-on-black. Use of the Windows Help function is extensive, providing an online manual as well as tips on getting the most from the information provided by *MPO96*. □

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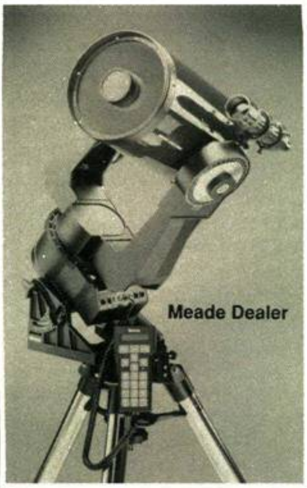

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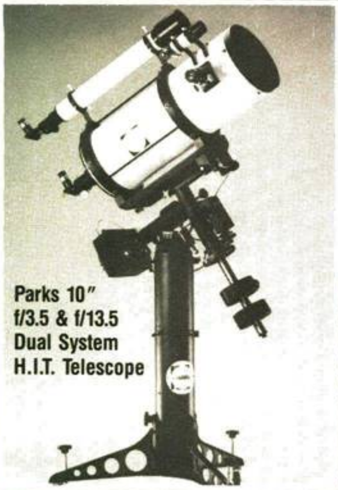

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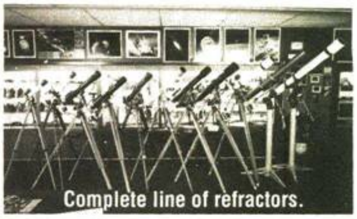

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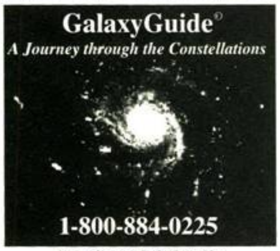

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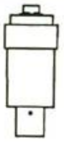

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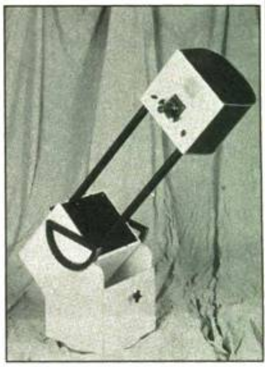

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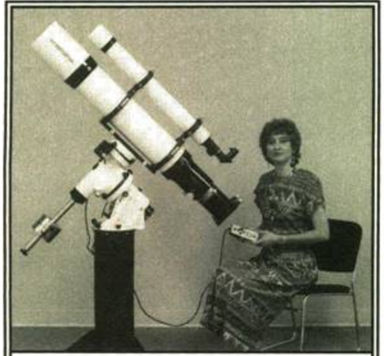

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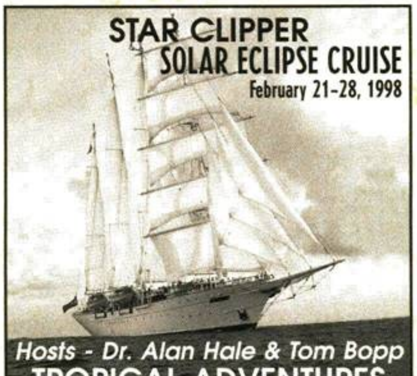

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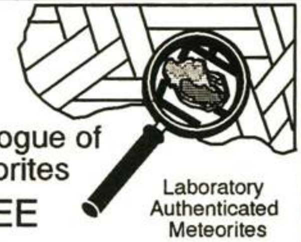

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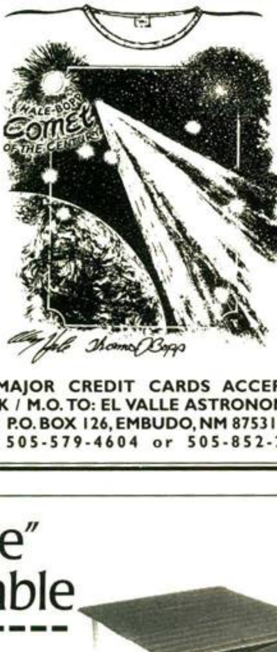

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☐ **AstroCalc Super**™ Input time, date & lat./long. & get for Sun, Moon & planets: Right Asc./Dec., Alt/Azm, Ecliptic Lat./Long., Angular size, Fraction Illum., Elongation, Rise/Set Times, Distances from Sun & Earth, Sidereal Time, Twilight Times, Helio and Geocentric Data. Automatic repetitive calculations(solar/planetary positions or any other data for every hour or day, etc.). Output to text file or printer. Plots of Sun, Moon & Planets to screen, printer. Helio & geocentric plots of longitude & distance or lat. & dist., RA & Dec. or alt & azm. IBM **$79.95**

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☐ **LodeStar Plus**™ Powerful, versatile tool to bring the universe to your computer, from 9999BC to 9999AD for any location. Includes 9,000 stars, all 7840 NGC objects, Messier objects, Sun, Moon & planets. View from 180 deg. to 0.18 deg. See solar/lunar eclipses, planetary conjunctions, occultations, transits. Get Alt/Az, RA/Dec. Find or identify any NGC object, star or planet. For high accuracy, calculate precession, refraction, aberration, nutation, parallax. Pick from 300 printers. IBM **$99.95**

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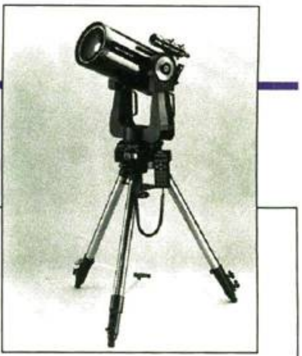


7-inch LX200 Maksutov-Cassegrain

Meade introduces a 7-inch f/15 Maksutov-Cassegrain into its line of LX200 computerized alt-azimuth telescopes. The Maksutov type of optical design produces a precisely flat field of view for sharper photos. Its f/15 focal ratio yields a long focal length, making the scope ideal for lunar and planetary photography. This hybrid Maksutov-Cassegrain incorporates a secondary mirror that never needs adjustment into the center of a front meniscus lens. The LX200 mount uses a built-in computer to track the sky continuously by simultaneously changing motion in altitude and azimuth. The system comes loaded with the positions of over 64,000 celestial objects, each accessible through a GO TO slew mode that moves the telescope at a rate of 8° per second.

Meade Instruments Corporation, 16542 Millikan Avenue, Irvine, CA 92714-5032; (714) 756-2291; fax: (714) 756-1450. The 7-inch LX200 Maksutov-Cassegrain telescope: $2,995, plus packing and shipping.

Earth Season Model

The Blue Planet Season Globe models the seasons our planet goes through over a year's time. A globe with political boundaries sits angled in an acrylic stand, inclined 23½° like the real Earth. Turning a calibrated month dial changes the globe's seasonal aspect. The globe also rotates on its axis to mimic daily motion. As a bonus, the calibrated month dial displays what southern constellations are on the meridian at local noon.

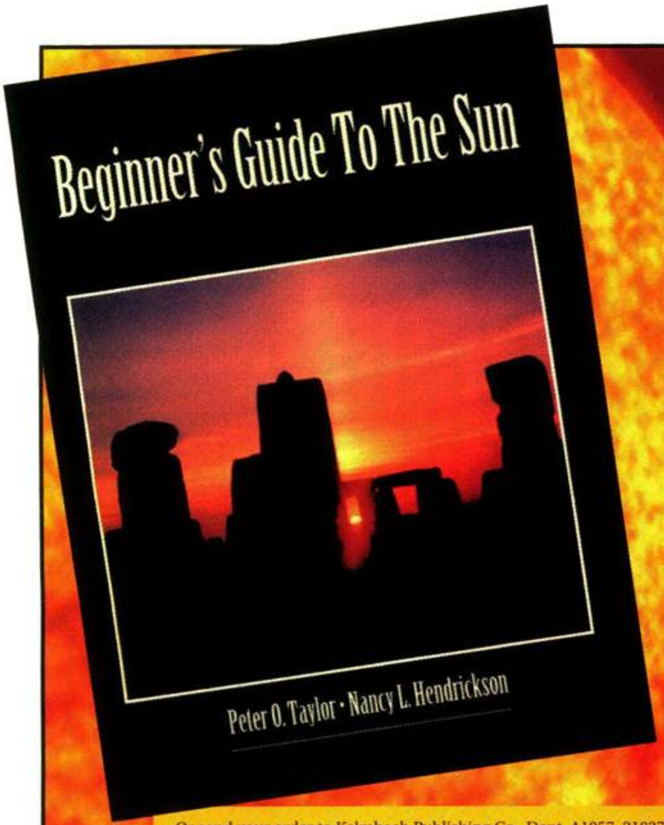
Scientific Universe Products, 126 S. Helberta Ave., Unit #4, Redondo Beach CA 90277; voice and fax: (310) 937-4763. The Blue Planet Season Globe: $49.

New Products presents announcements issued by manufacturers. ASTRONOMY assumes no responsibility for the product information supplied. Prices are suggested retail. Suppliers should send announcements and color photographs to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com.

Expanded Line of Eyepieces

Optical designer Al Nagler squeezed enough efficiency out of his four-element Plössl design to introduce Tele Vue's next generation of 1¼-inch Plössl eyepieces. The eyepieces feature a 50° apparent field of view and come in 8mm, 11mm, 15mm, 20mm, and 25mm focal lengths. Each has fold-down rubber eyeguards, top and bottom caps, blackened lens edges to reduce internal reflection, and chromed barrels machined with a set-screw groove to positive-lock in a telescope's focuser. All eyepieces come threaded to accept 1¼-inch filters. The new 2x and 3x Barlow lenses also accept 1¼-inch filters, something previous designs haven't offered. All eyepieces and Barlows are optical bench-tested at f/4 to assure optimal performance.

Tele Vue Optics, 100 Route 59, Suffern, NY 10901; (914) 357-9522. 8mm, 11mm, 15mm Plössl eyepieces: $125; 20mm and 25mm Plössl eyepieces: $140; 2x and 3x Barlow lenses: $160.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FILTER OF THE MONTH: LUMICON DEEP-SKY

LUMICON H-BETA
LUMICON OIII
LUMICON UHC
LUMICON DEEP-SKY

USE THIS ONE TO SEE M-83

FILTER OF THE MONTH: The LUMICON Deep-Sky Filter will help you see the lovely barred spiral galaxy M-83 in Hydra. Spiral structure should be visible in 13" or larger telescopes in dark skies.

TELE VUE™

NEW! Bino Vue Binocular Viewer

Genesis-SDF 4" f/5.4 apochromat	$1950
Pronto 70mm f/6.4 apochromat w/2" diagonal	$939
Pronto 70mm f/6.4 w/45° erecting prism	$789
NEW! Bino Vue binocular viewer	$899
Gibraltar mount with ash wood tripod	$495
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	$79
8, 11, 15mm Plossl **$89**, 20, 25mm	$99
2.0x or 3.0x Tele Vue Barlow Lens	$115
2" Giant Barlow - 2x	$179
32mm Plossl, widest true field in 1¼"	$119
55mm 2" Plossl, widest possible field	$229
15mm Wide-Field, 1¼" eyepiece, 65°	$139
19mm Wide-Field, 1¼" eyepiece, 65°	$149
4.8mm Nagler, 82° field, 1¼" eyepiece	$169
7mm Nagler, 1¼" eyepiece, 82° field	$219
9mm Nagler, 82° field, 1¼" or 2"	$239
13mm Nagler, 82° field, 1¼" or 2"	$299
12mm Nagler, Type II, 82°, 1¼"/2"	$279
16mm Nagler, Type II, 82°, 1¼"/2"	$299
20mm Nagler, Type II, 82°, 2" only	$375
1¼" Paracorr Visual Coma Corrector	$159
2" Paracorr Visual Coma Corrector	$249
15mm Panoptic 1¼", 68° field	$209
22mm Panoptic 1¼"/2", 68°	$269
27mm Panoptic 2", 68° field	$319
35mm Panoptic 2", 68° field	$349

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

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Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

Specify Lens Size	**H-Alpha**	**(DS)**
46, 48, 49mm	**$59.00**	**$119.50**
52, 55, 58, 62mm	**$69.00**	**$119.50**
67, 72, 77mm	**$79.00**	**$299.50**
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Hypered 2415 film, 36 exp .. **$11.95, $3/$32**

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LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$39.50** 1.52" **$45.00** 1.83" **$49.50**
2.14" **$59.50** 2.60" **$75.00** 3.10" **$99.50**

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90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	$99.50
2" (1.83" mirror)(see photo above)	$189.50

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain." ***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

"Consistently performed well on all emssion and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE*, July 1995**

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"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE*, July 1995**

SEE THE HORSEHEAD!

*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae ..."* ***SKY & TELESCOPE*, July 1995**

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

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0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	$59.50
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**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

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†U.S. Patent 4,473,636

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Specify Camera and Telescope type.

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Full aperture. Installs in seconds. Specify 2" or 1¼".

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3X Relay Diagonal (see photo)	**$99.50**
Illuminated reticle eyepiece, pulsed	**$109.50**

Guider for Hasselblad **$409**, Mamiya 645 **$199**
Pentax 6X7 **add $119**; Pentax 645 **add $139**

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For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

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For Celestron-11, C-14, and the 10-12" Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
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3. **Declination motor** (state telescope type) **$109**
4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.
5. **LUMICON EASY-GUIDER** (selection to left)
6. **LUMICON 48mm DEEP-SKY FILTER $119.50** This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.
7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

HYPERSENSITIZED FILM

Scotch
1000
SR1000
TP 135-36

HYPERED FILM IS 2-10X FASTER!

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Fuji G800 fine grain color neg.	**24**	**$13.95**
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Fujichrome RD100, fine grain slide	24	**$12.95**
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RICH FIELD! 2° in 8" SCT

NOW ONLY
$99.50

LUMICON Rich-Field Viewer on C-8 with LUMICON 2" star diagonal and 2" eyepiece.

The LUMICON Rich-Field Viewer fits **all** commercial Schmidt-Cassegrain telescopes. It has a high-performance coated achromatic focal reducing lens with 50mm or 80mm clear aperture for **totally unvignetted viewing** with 2" or 1¼" eyepieces. It is available in several combinations depending on the eyepiece and field-of-view you desire (see chart below).

LUMICON Rich-Field Viewer	**$99.50**
Giant Rich-Field Viewer (10-14") ..	**$250.00**

Optional Eyepiece	TRUE FIELD	Price
Meade 32mm Plossl	1.4°	**add $99**
Meade 32mm 2" Wide-Field†	1.9°	**add $459**
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†Includes 2" enhanced aluminum Star Diagonal (may not reach focus on some telescopes).

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2"	**2/$2**	12½", 12⅞"* ...	**$20**
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*Fits Odyssey		21" (Odyssey-II)	**$35**

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NEW! 8" - 10" LX50

8" LX50
$1195
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Meade 8" LX200 Telescopes

LX50 - includes dec. motor, hand controller. **LX200** - full computer control w/64K obj. mem. **Tripod:** extra for LX50; included for LX200 *NOTE:* A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your LX200.

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See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

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*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

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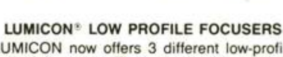

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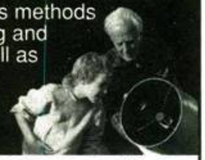

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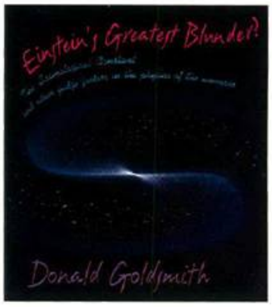
ASTRO BOOKS

The Universe Explained

by Stephen H. Peters

Einstein's Greatest Blunder? The Cosmological Constant and Other Fudge Factors in the Physics of the Universe
Donald Goldsmith, (Harvard University Press, 1995), ISBN 0-674-24241-6, 216 pages, hardcover, $22.95.

Despite the subtitle, this book isn't really about fudge factors. Rather, it is an introduction to current questions in cosmology for those who think the subject is only for experts.



Donald Goldsmith, an astrophysicist and popularizer of astronomical issues, puts today's headlines into perspective by providing a brief history of cosmology for the general reader. In this book he considers four prominent questions facing astronomers and cosmologists today: How did the universe form large structures in the time it has existed? What is the ultimate fate of the universe? What is dark matter? And how strong is the evidence for a cosmological constant greater than zero?

He discusses how the universe's structure relates to its age by first explaining how Margaret Geller and John Huchra surveyed the sky to map the positions of thousands of galaxies, and in the process discovered large-scale structures. This raises the question of whether the universe has been around long enough to form these structures. Goldsmith explains how the determining factor in the age of the universe is the Hubble constant, which tells how fast the universe is expanding.

Goldsmith next describes how the Hubble Space Telescope's Virgo Cluster distance result announced in 1994 is the key to determining the age of the universe. It helps refine estimates of the age of the universe but does not constitute a crisis in cosmology. Goldsmith shows how, under certain conditions, Einstein's cosmological constant – an energy that arises from the vacuum of space – may play a pivotal role.

The answer to the second question, whether or not the universe will continue expanding forever, lies in the density of the universe. Goldsmith explains how Einstein's general theory of relativity affects space and how the cosmological constant may play a role here too. The curvature of space will affect the density of matter, and all of this can be calculated if the Hubble constant is known.

These issues segue nicely into the third question, the nature of dark matter. Goldsmith launches into an explanation of Alan Guth's inflationary model and how this indicates the existence of large quantities of missing mass.

The fourth question, whether or not there is a cosmological constant, is not discussed in any great detail on its own, but is interwoven into the other three questions.

Goldsmith displays a wonderful gift for simplifying the complex. He takes the most involved problems in astronomy and reduces them to their essentials in language that any reader can understand, although it might take a couple of readings to fully comprehend some passages.

I have only a couple quibbles with the otherwise fine text. It was Aristarchus, not Eudoxus, who developed the first heliocentric model of the solar system. And for some reason Goldsmith refers to the Hertzsprung-Russell diagram only as the temperature-luminosity diagram. Why not give the creators of this very useful tool their due? Nevertheless, this book is an excellent introduction to cosmology. □

Stephen H. Peters is a professor of library science at Northern Michigan University.

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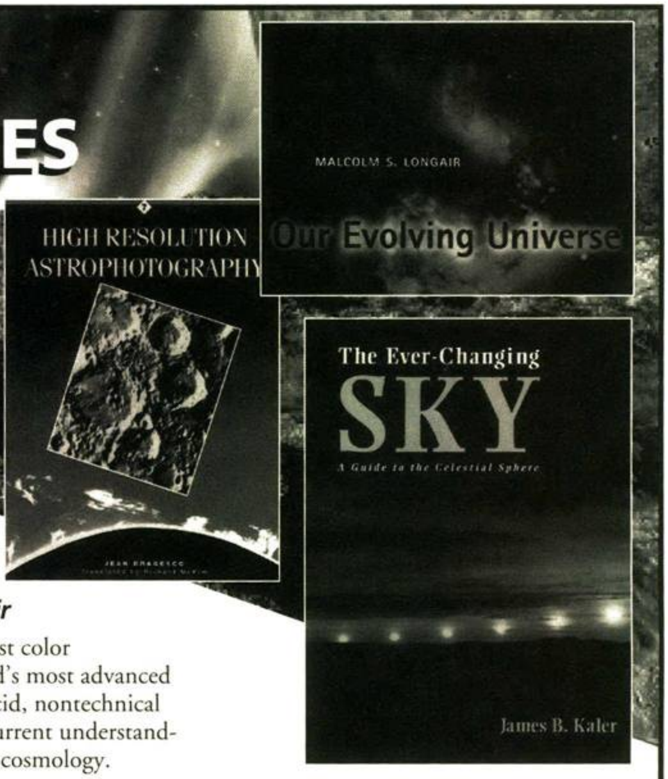

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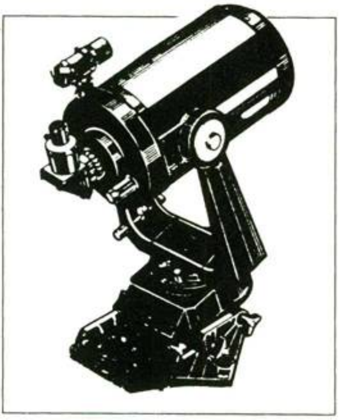

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For more detailed information on these telescopes, contact a Celestron dealer or Celestron.

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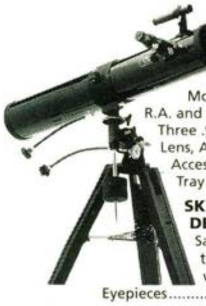

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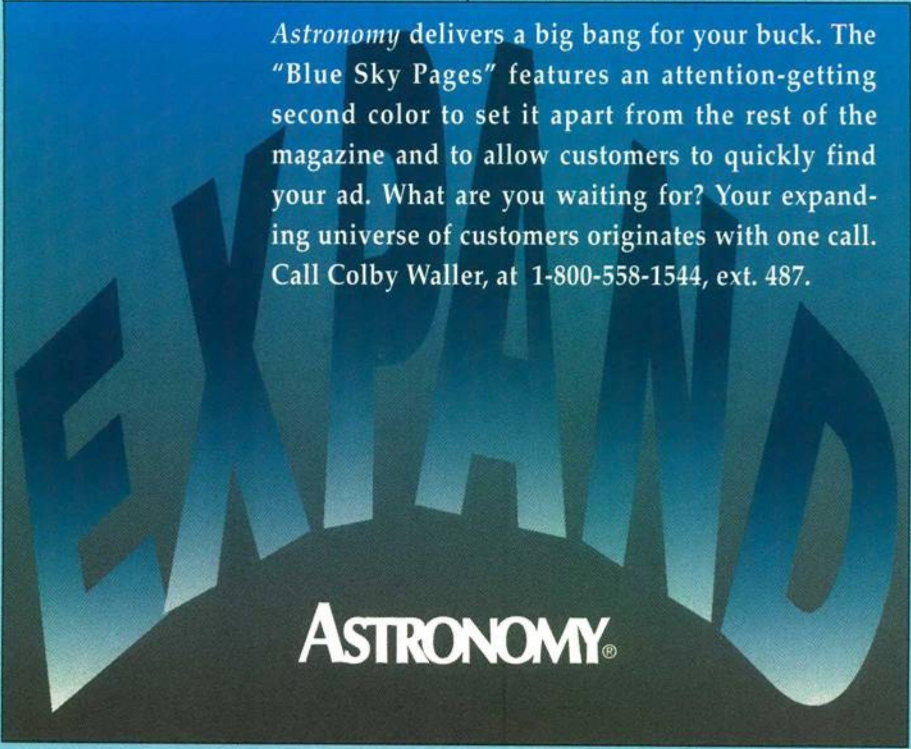

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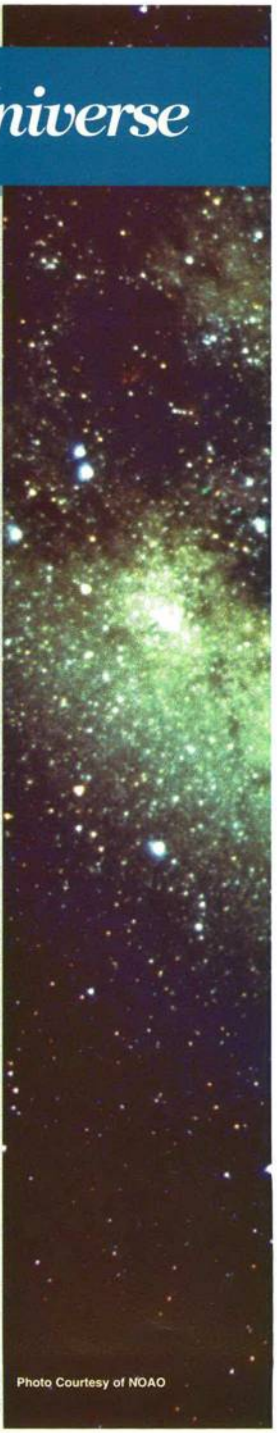
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April 22
Astronomy Day, Bartram Park, Pensacola, Florida. Sponsored by Escambia Amateur Astronomers' Assocation. Contact Wayne Wooten, (904) 477-8859.

April 26-27
10th Annual NIAGfest, Camp Crosley, North Webster, Indiana. Cosponsored by the Northern Indiana Astronomical Groups and the Great Lakes Region of the Astronomical League. Contact Kurt Eberhardt, 3370 E. Kenway Drive, Warsaw, IN 46580, (219) 269-6289.

April 27
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May 11
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May 17-18
Public Star Party, Lemon Lake County Park, Indiana. Sponsored by the Calumet Astronomical Society. Contact Craig Woodley, P.O Box 851, Griffith, IN 46319, (219) 836-4225.

May 22-24
I.A.P.P.P. Big Bear Symposium, Ramada Inn, San Bernadino, California. Sponsored by International Amateur Professional Photoelectric Photometry. Contact Lee Snyder, P.O. Box 3964, Incline Village, NV 89450, (702) 831-1931, snyder@rigel.physics.unr.edu.

May 24-27
Riverside Telescope Makers Conference, Camp Oaks, near Big Bear, California. Sponsored by the Riverside Telescope Makers Conference. Contact RTMC, c/o Fox Stephens, CPA's, 9045 Haven Avenue, Suite 109, Rancho Cucamonga, CA 91730, (909) 948-2205.

June 7-9
1st Latin American Workshop on Comets, Buenos Aires, Argentina. Contact the Asociación Argentina Amigos de la Astronomia, Av. Patricias, Argentinas 550, 1405 Capital Federal, Argentina, 541-863-3366, cometwor@aaaa.org.ar.

June 8-15
6th Annual Grand Canyon Star Party, South and North Rims of the Grand Canyon, Arizona. Sponsored by the Tucson Amateur Astronomy Association. Contact TAAA, 1122 East Greenlee Place, Tucson, AZ 85719, (520) 293-2855, ketelsen@as.arizona.edu.

June 14-16
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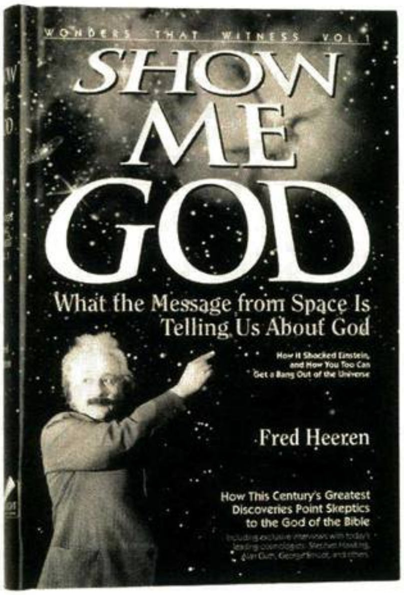
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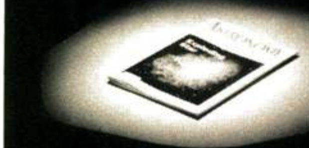

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MEETINGS & EVENTS

June 15
Annual Solstice Star Party, Northern Cross Observatory, Hartland, Michigan. Sponsored by the Warren Astronomical Society. Contact Doug Bock, Warren Astronomical Society, P.O. Box 1505, Warren, MI 48090-1505, (810) 750-0273.

June 16-22
Solstice Markers and the Anasazi Sky, Cortez, Colorado. Sponsored by Crow Canyon Archaeological Center. Contact CCAC, 23390 Road K, Cortez, Colorado, 81321, (800) 422-8975, ext. 146.

June 18-21
General Assemblies and Congress on Amateur Astronomy Today, Lucerne, Switzerland. Sponsored by the International Union of Amateur Astronomers. Contact Andreas Tarnutzer, Hirtenhofstrasse 9, CH-6005 Luzern, Switzerland.

June 29
How Things Fly, National Air and Space Museum, Washington, D.C. Contact the National Air and Space Museum, Office of Public Affairs, MRC 321, Room 3733, Washington, DC 20560, (202) 357-1552.

July 20-26
20th International Congress of History of Science, Montpellier, France. Sponsored by the University of Montpellier Planetarium. Contact Dr. Jean Michel Faidit, The University of Montpellier, B. P. 1088, 34007 Montepellier, France.

July 29-August 17
Youth Camp, Coucouron, France.Sponsored by the International Astronomical Youth Camp. Open to English-speaking youths ages 16-24. Contact Gwendolyn Meeus, Schapenstraat 11, 3000 Leuven, Belgium. ☐

Please submit announcements at least four months in advance to Meetings and Events, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612, or jsherwin@astronomy.com.

RESOURCES & PHOTOFACTS

Big Bang (page 34)

Hyperspace, by Michio Kaku (Oxford University Press, 1994). An intro to wormholes, parallel universes, and ten-dimensional space-time.

"The Self-Reproducing Universe," by Andrei Linde, *Scientific American*, November 1994. How multiple universes can arise from nothingness.

"The Universal Wizard," by John Horgan, *Discover*, March 1992. Part biography of Andrei Linde and part voyage into multiple universes.

Meet the Milky Way (page 72)

The Universe from Your Backyard, by David J. Eicher (Cambridge University Press, 1988). Constellation-by-constellation coverage of deep-sky objects spanning the Milky Way.

Stars and Galaxies, edited by David J. Eicher (Kalmbach Books, 1992). This lavishly illustrated work presents challenging Milky Way nebulae and clusters not normally encountered in the literature.

Starsplitter (page 78)

Star Testing Astronomical Telescopes, by Harold Suiter, (Willmann-Bell, 1994). An excellent primer on how to evaluate astronomical optics.

Comet Crap Shoot (page 82)

Check out the JPL Comet Observation Home Page, which features information and images of hundreds of comets: **http://encke.jpl.nasa.gov**

IAU Circulars, by the Central Bureau for Astronomical Telegrams. Information of recently discovered comets, asteroids, and supernovae. Contact Mail Stop 18, Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138, or access the home page: **http://cfa-www.harvard.edu/cfa/ps/cbat.html**.

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p. 56: Jean Dragesco 14-inch SCT at f/60, Tech Pan film, ¼-second exposures on December 6, 21 and 30, 1981; **p. 62:** Donald Parker, March 22, 1991; **p. 64:** Stephen Walther; **p. 70:** Patrick Wiggins, 14-inch SCT, Ektachrome 400 film, 60-minute exposures on July 14, 15, and 17, 1993. ☐

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Miscellaneous Wanted

Science teachers request your favorite web sites for students and teachers to access resources for projects/ reports. All science fields welcome. gcolyar@northcoast.com

Organization Announcements

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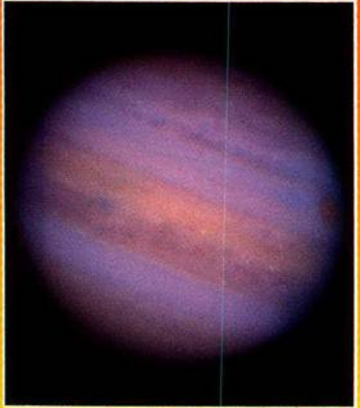

Charles Capen

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To most observers, summer brings to mind rich star clusters and glowing gas clouds. But if you stay up late, summer also offers a bounty for galaxy hunters.

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READER REPORTS

A Flurry of Comets

With comets, when it rains, it pours. First came Comet Hale-Bopp (1995 O_1), discovered in July 1995 and brightening to a predicted naked-eye visibility this autumn and next spring. Then came a string of pretty good comets that delighted observers with telescopes and binoculars. Comet Bradfield (1995 Q_1) peaked at 7th magnitude in September 1995. Comet P/Schwassman-Wachmann 3 erupted in September, surprising observers who glimpsed its brief appearance as it shone at 5th magnitude rather than the expected 10th magnitude.

Comet P/De Vico was recovered the same month and rose to brief naked-eye visibility in October, sporting a bright nucleus and a tail spanning several degrees. Comet P/Honda-Mrkos-Pajdusáková reached a respectable 8th magnitude in December, revealing a stubby tail. Faint Comet Jedicke (1996A_1) was discovered by Robert and Victoria Jedicke on January 14, 1996. Comet Hyakutake (1995 Y_1) approached 9th magnitude in February 1996, just about the time Comet Szczepanski (1996 B_1), also glowing at about magnitude 9, was discovered.

Finally, a *second* Comet Hyakutake (1996 B_2), pre-

Lunar Craters Eudoxus and Aristoteles

by Cesar Descordes
(9-inch Cassegrain at f/66, Tech Pan film, 1½-second exposure taken September 14, 1995)

Comet Jedicke (1996 A_1)

by Tim Puckett and Ingrid Siegert
(12-inch SCT at f/7, ST-6 CCD camera, 300-second exposure taken January 22, 1996)

Comet P/Honda-Mrkos-Pajdusáková

by Tim Puckett and Ingrid Siegert
(12-inch SCT at f/7, ST-6 CCD camera, 300-second exposure taken December 28, 1995)

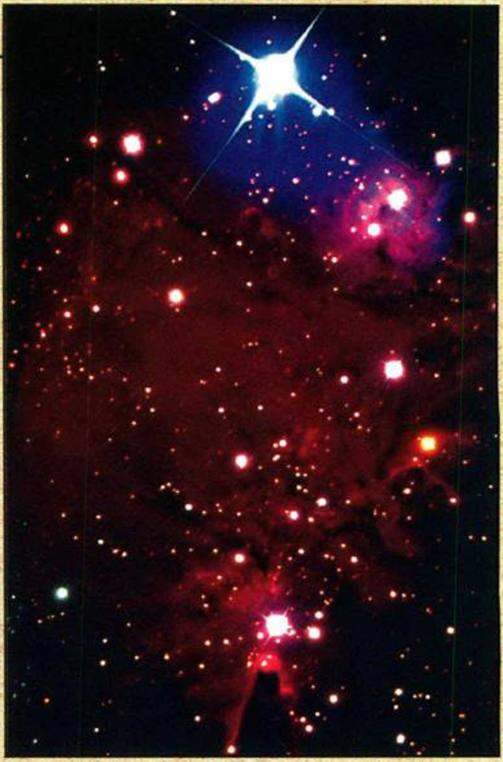
dicted to rise to 1st magnitude as it skimmed just 0.1 AU past Earth in March, was discovered on January 30. In short, it has been a superb last few months for moderately bright comets.

Hale-Bopp spent the last weeks of 1995 and first weeks of 1996 hiding near the Sun in our sky. Richard Didick of Rehoboth, Massachusetts, observed the comet with a 10-inch f/4.5 reflector at 91x in August and September 1995. In late August he described it as small, evenly diffuse, and with a fan-shaped coma in p.a. 335°–345°.

Didick observed Bradfield in October with the same telescope at 47x and found it on the 26th to be "evenly diffuse, with a slight brightening north of center; the comet has no defined shape." His observation of De Vico, made two days earlier, recorded a tail "extending out from the round coma, appearing as a spike 8' long, and widening as it becomes fainter away from the comet's center."

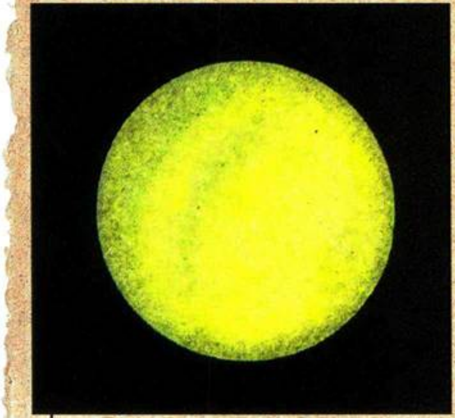
Dale Johnson, an employee of the U.S. Embassy in Lusaka, Zambia, enjoyed viewing Schwassman-Wachmann 3 with his 7x35 binoculars and made a series of sketches throughout October showing the comet's motion. Johnson initially thought he had discovered a comet. □

ASTRONOMY wants to hear about your observations of the sky. Send reports, sketches, photographs, and disks to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187–1612. Please label each photo with name, address, and social security number. You may send written reports and images via the Internet to: rreports@astronomy.com



The Cone Nebula (NGC 2264)

by James R. Foster
(14-inch SCT at f/7, hypersensitized Tech Pan film, tricolor image made from a total of 11 hours' exposure time)

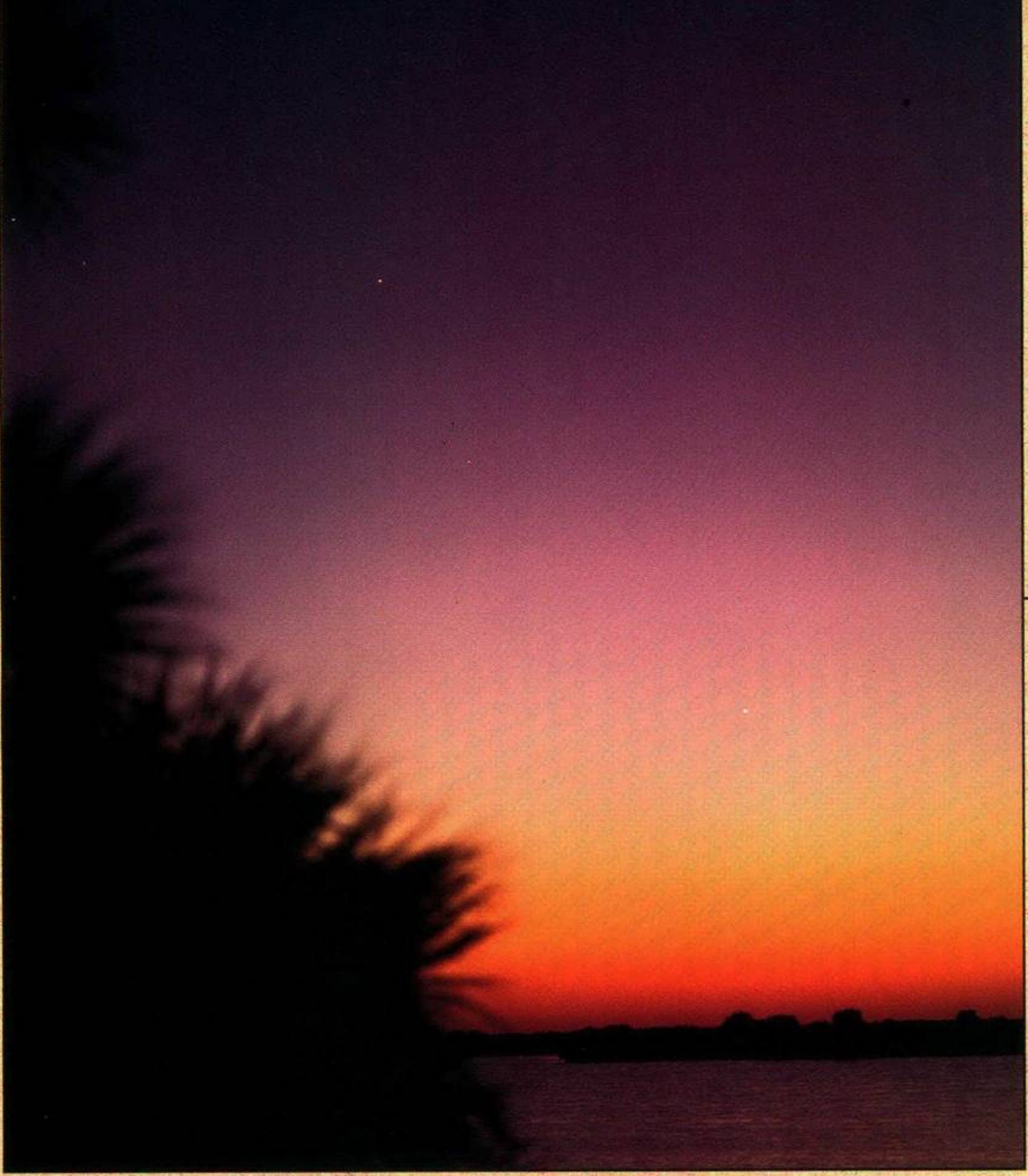


Uranus Viewed with the 36-inch Clark Refractor

by Thomas A. Dobbins
(36-inch refractor at 1,176x, Lick Observatory, sketch made on August 9, 1995)

The Pleiades (M45)

by Dave Holland
(8-inch f/5 reflector, hypersensitized Kodak Royal Gold film, composite of two 75-minute exposures)



Venus, Mars, and Jupiter

by Ernie Sangraw (165mm lens at f/2.8, Fuji Provia film, taken November 9, 1995, at Merritt Island National Wildlife Refuge, Florida)

Aurora over James Bay, Canada

by Michel Tournay (16mm fisheye lens at f/2.8, Fuji Super G 200 film, 30-second exposure taken in March 1995)

The Orion Nebula (M42)

by Giovanni Dal Lago (11-inch SCT at f/3, Starlight Xpress CCD camera, composite of seven 10-second exposures)

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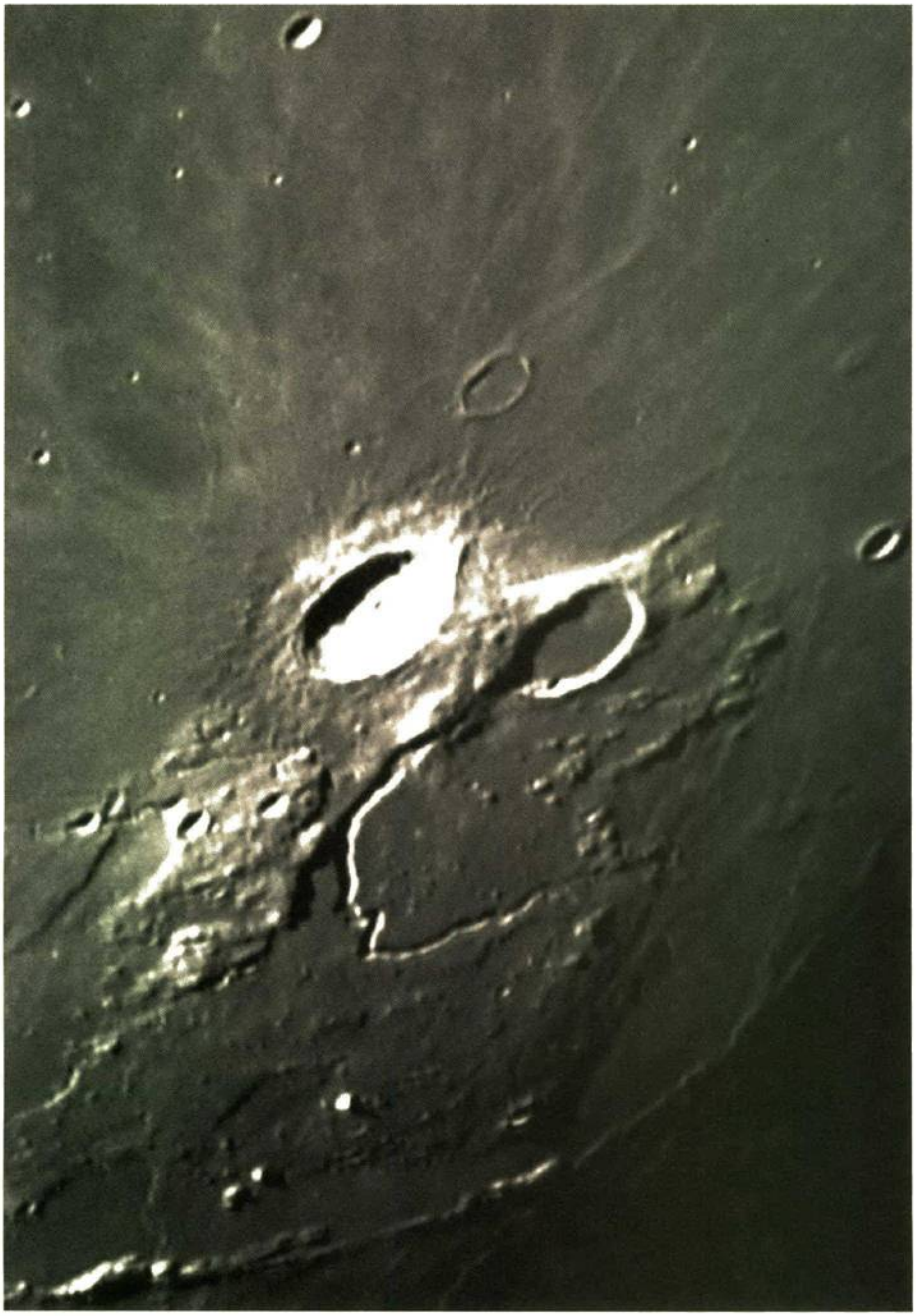

Schröter's Valley and Craters Aristarchus and Herodotus

by Thierry Legault
(10-inch Cassegrain at f/33, Hi-Sis CCD camera, 1⁄15-second exposure taken November 10, 1995)

The largest winding valley on the Moon, Schröter's Valley appears like a meandering dry river bed. The valley's width ranges from 1,500 yards to 6 miles and stretches 100 miles, reaching depths of 3,000 feet below the lunar surface. The prominent, dish-shaped crater Aristarchus (left) spans 25 miles; Herodotus, to its right, is a flooded crater 20 miles across.

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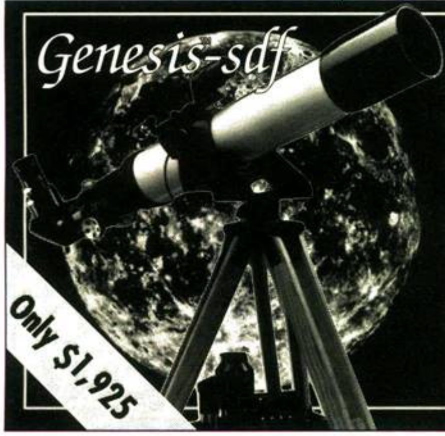

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NEW TELE VUE GOODIES!

NEW! PLÖSSLS & BARLOWS

Buying patented Tele Vue Plössls is an investment you'll never regret. Every Tele Vue eyepiece is designed by Al Nagler, and every single one is inspected optically & cosmetically. That's how we insure, compared to any competing models, we're "tops in the field."

New Plössl models feature fold-down eyeguards, parfocalization, full multi-coatings, contrast enhancing black lens edges, anti-reflection & filter threads and lens caps.

New 1¼" parfocal Barlows add only a magnification "window" to your image. They feature filter threads, multi-coatings, & magnification identity ring.

New Focal Lengths: 25mm, 20mm, 15mm, 11mm, 8mm
New 1¼" Barlows: 2x & 3x

QWIK-POINT AROUND THE UNIVERSE

Tele Vue Qwik Point

Great Features: Day/Night Sighting, Low Cost

Qwik Point provides DAY/NIGHT sighting for any telescope, spotting scope, or binocular. With the flick of a switch, the illuminator changes from bright to dim. The night mode includes a variable brightness adjustment. Easy X and Y adjustment means qwik setup. An adapter bar, battery and mounting hardware for Tele Vue and other telescopes is included. Priced so attractive, you'll want Qwik-Point on every scope you own!

BINO VUE, IT'S NATURE'S WAY OF VIEWING

Enjoy an entirely new observing experience. "The view through a telescope is always better with two eyes," wrote John Shibley in his Astronomy magazine review"...while looking at the open cluster M11 in Scutum...my mind shaped the view into a 3-D spattering of tiny star points."

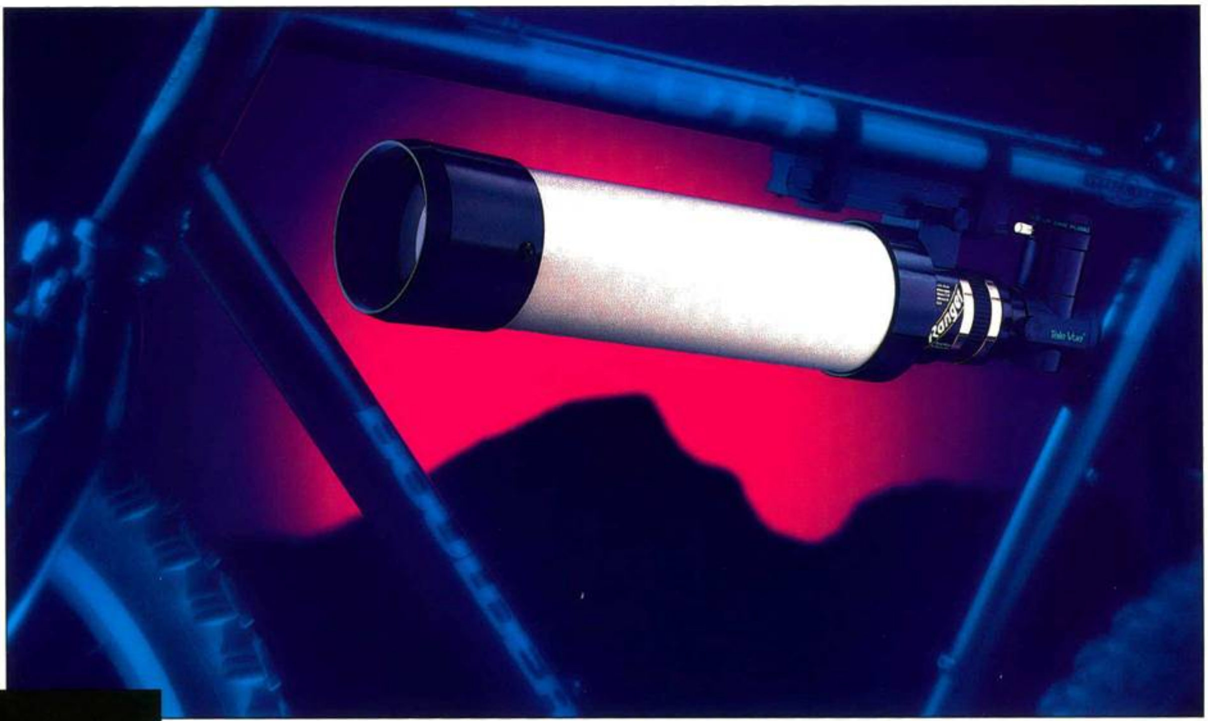
Bino Vue converts any scope into a spectacular binocular and features straight through viewing and no focus shift when interocular separation is adjusted. "Bino Vue sits in a league of its own among binocular viewers."

Stereo Viewing Comfort: Add new dimension to observing

Tele Vue®

Product flyer free, or send $3 for full-line literature.
Tele Vue Optics, Dept A, 100 Route 59, Suffern, NY 10901. (914) 357-9522.

NEW TELE VUE RANGER!



HAVE RANGER, WILL TRAVEL

FEATURES: Rugged construction, 3.5 lbs., 480mm f.l. E.D. obj., 12x to 200+ power, Plössl eyepiece

"We put Tele Vue's new 70mm f/6.8 refractor through its paces and discovered an ideal travel telescope for astronomy, wildlife, or sports." — *S&T, Nov. '95. Ranger combines light weight with all metal construction, attractive cost with fine American craftsmanship, and rich field views with diffraction limited, performance — satisfying owners of any experience and interest level.*

Active users agree. "My new Ranger is great! The wide field, pinpoint star images and portability make it a joy to use — both at night and during the day. I used to have an 8" Dobsonian, but I enjoy Ranger more." — *Tom Gregory, CA*

S&T's reviewer observed: "Saturn's moon Titan as a pinpoint, and a clear edged planetary disc of pale beige yellow with hazy equatorial banding...the tiny, elaborate trapezium of M29 stood out clearly...the companions of Andromeda, M32 and NGC205 showed clearly...the northern component of the Double-Double showed plenty of black space — this with a scope I picked up with one hand and carried across the yard!"

Ranger with optional ash Panoramic Mount, Qwik Point & Glare shield. Brass Ranger shown with 90° mirror diagonal on optional walnut Panoramic Mount.

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CELESTRON® REFRACTORS

Firstscope 80 EQ – The best buy in refracting telescopes – high performance and unbeatable price.

The **Firstscope 80 EQ** telescope is a good choice for the more serious beginning astronomer. An 80mm (3.1") aperture. The objective is an air-spaced achromat designed to yield the finest images available in this class of instrument. It has a 910mm focal length (f/11.4).

The equatorial mount is stable and includes setting circles in both axes as well as slow-motion cables in both axes for easy tracking. The wood tripod is adjustable in height and includes an accessory tray.

For astronomy you can enjoy breathtaking views of the Moon, Saturn with its ring structure, Jupiter and its belts and hundreds of deep-sky objects including galaxies, nebulae and star clusters. With a solar filter (optional) you can observe activity on the Sun. For terrestrial use, enjoy vistas from view homes or take your instrument out in the field to take advantage of our natural environment up close.

Standard accessories include a 6x30 Finderscope, 1¼" Focuser, 25mm SMA Eyepiece – 1¼" (36x), Star Diagonal – 1¼". Weight is 24 lbs.

4" REFRACTORS

Celestron offers two models of 102mm (4") equatorial refractor telescopes. These telescopes are for the more serious astronomer who appreciates superb optics and ultra-stable mounts.

The Great Polaris (GP) German equatorial mount is standard. Both axes have precision 144-tooth lapped worm gears for very smooth motion. The adjustable height, very rigid wood tripod has excellent vibration dampening characteristics and has a handy accessory tray.

The GP mount has a built-in illuminated polar alignment scope for fast polar alignment.

The premium optics of the **GP-C102** are made in Japan to rigid standards. It has a focal length of 1000mm (f/9.8). The **GP-C102-ED** model features Super ED glass to yield exquisite images of very high contrast and resolution with virtually no chromatic aberration. The ED unit has a focal length of 920mm (f/9) and has multi-coatings.

Standard accessories (the same on both models), include a 20mm Eyepiece – 1¼", 6x30 Finderscope with an 8° field and a Star Diagonal – 1¼". Weight is 39 lbs.

Optical tube assemblies of the 4" refractors are available separately and include tube rings, mounting plate and finderscope.

CELESTRON REFRACTING TELESCOPES:

The 60mm (2.4") refractor is the most popular telescope size for the beginning astronomy enthusiast or for casual gift-giving. It can introduce newcomers to the exciting hobby of astronomy at an affordable price.

FIRSTSCOPE 60

A 700mm focal length (f/11.7) telescope which contains all glass optical components with coated optics.

The glossy black telescope optical tube is made of aluminum. The sturdy altazimuth mount has a slow-motion control rod for vertical adjustments. The rigid, adjustable wood tripod includes an accessory tray.

Standard accessories include a 20mm H – .96" Eyepiece (35x), 6mm SR – .96" Eyepiece (117x), 2x Barlow Lens – .96", 5x24 Finderscope and a 90° Diagonal.

FIRSTSCOPE 60 DELUXE

The same as the Firstscope 60 except that all the .96" items are replaced with a **hybrid 1¼" diagonal and two 1¼" eyepieces** – 25 SMA (28x) and 10mm SMA (70x).

Celestron offers two 60mm equatorial refractors – the Firstscope 60 EQ and the Firstscope 60 EQ Deluxe.

FIRSTSCOPE 60 EQ

Similar to the Firstscope 60 but the focal length for this telescope is 900mm (f/15).

Standard accessories include a 20mm H – .96" Eyepiece (45x), 12.5mm H – .96" Eyepiece (72x), 2x Barlow Lens – .96", 6x24 Finderscope and a 90° Diagonal. Weight is 11 lbs.

FIRSTSCOPE 60 EQ DELUXE

The same as the Firstscope 60 EQ except that all the .96" items are replaced with a **hybrid 1¼" diagonal and two 1¼" eyepieces** – 25mm SMA (36x) and 10mm SMA (90x).

The 1¼" accessories give you sharper images, a wider field of view and better eye relief. Weight is 11 lbs.

Celestron offers a premium grade 80mm (3.1") altazimuth refractor – **The Premium 80.** The premium built optics are made in Japan.

The Premium 80 is an ideal first telescope for the more serious beginning astronomer or terrestrial observer.

Its easy-to-use altazimuth mount includes slow-motion controls in both axes with flex cables allowing quick and easy pointing and tracking. The supplied attractive and very sturdy wood tripod is adjustable in height.

Standard accessories include a 26mm multi-coated Plössl – 1¼" Eyepiece (35x) for a wide field of 1.4°, high quality 6x30 Finderscope and a versatile 45° Erect Image Diagonal – 1¼". Weight is 18 lbs.

CELESTRON® *For more detailed information on these telescopes, contact a Celestron dealer or Celestron.*

Celestron International • 2835 Columbia Street, Torrance, CA 90503 • (310) 328-9560 • FAX (310) 212-5835